Senior Honors Project

Department of Economics

"Looking for Environmental Kuznets Curves in Countries that Ratified the Paris Agreement"

Haley Carner

Spring 2019

Abstract

This study utilizes data from 194 countries that ratified the Paris Agreement, showing they are committed to reduces greenhouse gas emissions. In order to understand which nations are likely to comply to the goals set forth in the agreement I examine the relationship between income per capita and greenhouse gas emissions for these nations based on the framework of the Environmental Kuznets curve. In previous literature the actual shape of the EKC is contested, some found empirical evidence that it appears as an inverted u-shape while others suggested that it showed in an n-shape curve. Using a two-way fixed effect panel regression with both of a quadradic model and a cubic model to test the best way to fit the relationship. I found that for Carbon Dioxide and Nitrous Dioxide fit the quadratic model better while the cubic model was more significant for methane. After determining the shape the relationship took I calculated the turning points for each emission. Methane did not end up having any turning points because while the cubic model fit better, it the rate of increase changed but never actually decreased. As for carbon dioxide and nitrous oxide the turning points calculated were $3,874,782.15 and $79,221.26 respectively. These turning points are overestimated because the explanatory variables included did not include variables that explain the EKC so results were skewed to the right. Due to the overestimation of the turning points it was not possible to identify countries that were unlikely to comply to the Paris Agreement. I suggest future studies in this area focus on explaining the reason EKC curves exist to get more accurate estimates and produce more complete recommendations.

Table of Contents

I. Introduction……………………………………………………………………………………..4

II. Literature Review…………………………………………………………….............................6

III. Theoretical Model……………..…………………………………………………………………..9

IV. Empirical Examination …..……………………..……………………………………………11

V. Results……………………………..…………………………………………………………..15

VI. Conclusions……………………………..……………………………………………………..18

VII. References…………………………………………………………………………………..…20

VIII. Appendices…………………………………………………………………………………….23

I. Introduction

Energy consumption and economic activities are closely interlinked, with energy being used for a variety of production processes and consumption activities within a nation. Currently, 80 percent of all energy production in the world is generated from fossil fuel sources. A byproduct of this production is the greenhouse gases (GHG), or gases that trap heat in the atmosphere, which are released into the environment. GHGs include Carbon Dioxide, Methane, Nitrous Oxide, and Fluorinated Gases. As of 2016, Carbon Dioxide made up 81 percent of total GHG emissions, Methane made up 10 percent, Nitrous Oxide 6 percent, and Fluorinated Gases 3 percent. Globally, the sector producing the largest share of GHGs is electricity and heat industry, which is responsible for about 25 percent of all emissions. Second, is Agriculture, Forestry, and other land use which is responsible for 24 percent, next is Industry and manufacturing at 21 percent, then Transportation at 14 percent, Buildings at 6 percent, and lastly, Other Energy is responsible for about 10 percent (EPA).

Recent observations show the global climate is changing because of increasing temperatures caused by GHGs. There are several effects that a warming earth can have on the environment including rising sea levels, changing weather patterns, heat waves, drought, wild fire, severe storms, and much more. While there is no consensus on how likely it is for all these things to happen or to what extent they would happen, Climate Change has become one of the most talked about global threats. A solution to the threat of Climate Change, the Paris Agreement was proposed in 2015. The agreement was reached by the United Nations Framework Convention on Climate Change Conference in Paris. One hundred and ninety four countries have signed or ratified this agreement which indicates their promise to put forth their best efforts to promote the reduction of emissions of GHGs coming from their nation as a means of lessening the damaging effects of climate change. Specifically, the Paris Agreement states its aims as:

i. "Keeping a global temperature rise this century below 2 degrees Celsius above pre-industrial levels"

ii. "Reach global peaking of greenhouse gas emissions as soon as possible", recognizing that it will take longer for developing countries to achieve this. .

Developing countries are likely to feel the pressure from being forced to cut back emissions because they are in the initial phase of their development. The environmental Kuznets curve theory which will be explained in detail later, in summary lays out the relationship between greenhouse gas emissions and GDP as an inverted u-shape implying that as income increases initially and then at a certain level of income a turning point is reached where income continues to increase but emissions decrease. So, developing countries are in the portion of the EKC where the relationship is positive, so there is really no economic incentive for the country to comply with the goals of the agreement. Other countries like the United States which have already reached peak emissions, according to some sources might find it's less of a burden on the economy to reduce emissions in later stages of development when income is more easily allocated to reduction GHG's

The Paris Agreement states that the parties agree to go through the proper channels internally to work towards the goals. This makes it even harder to coordinate actions because every country is going to have different approaches. Because of this difficulty in creating a cohesive action plan, on a global scale it is important to identify where each nation is relative to their peak emission points to best know where any support the U.N. decides to provide (mostly monetary aid) needs to be

To identify the situation of each party to the Paris Agreement , the concept of the Environmental Kuznets Curve defined above could be useful and. will be the framework of this paper. The main goal of this paper is to analyze the relationship that greenhouse gas emission levels have with per capita income. The results of this analysis could help Specifically, Secondarily, develop policy recommendations that would help nations work towards the goals put forth by the Paris Agreement.

II. Literature Review

The Environmental Kuznets curve shows the relationship between economic growth and environmental degradation can be plotted in an inverted u-shape, however some researchers have suggested it may actually be more accurately plotted in an n-shape curve. The EKC was first proposed by Grossman and Krueger (1991). While examining the impacts of the North American Free Trade Agreement on the environment they found empirical evidence that there is an inverted U-shape relationship between income per capita and certain measures of environmental degradation. Specifically, they found this relationship existed when using sulfur oxide emissions as the measure of environmental degradation. This relationship is what became known as an Environmental Kuznets Curve (EKC), named after Simon Kuznets who developed the hypothesis that the relationship between income and inequality levels experienced by a nation is represented by an inverted u-shape. Similarly, the EKC suggests that the relationship between income levels and environmental damage can also show an inverse u-shaped relationship.

Since Grossman and Kruger's initial findings in 1991, a lot of economist continued to study this hypothesized relationship empirically across various environmental degradation indicators, countries, and time periods. . Shafik and Bandyopadhyay (1992) focused their analysis on renewable resources such as air, water, and forests using 8 different indicators. These indicators include: (1) lack of clean water access, (2) lack of urban sanitation, (3) ambient levels of suspended particulate matter (SPM), (4) ambient sulfur oxides, (5) change in forest areas and annual deforestation rates, (6) dissolved oxygen in rivers, (7) municipal waste per capita and (8) carbon emissions per capita as environmental indicators. They found that for clean water access and urban sanitation, no further explanatory power was exhibited over a linear specification, that lack of water and urban sanitation always decrease as an economy grows. For Sulfur oxides and SPM's, the authors were able to confirm the EKC hypothesis and found the relationship did appear in the inverted u-shape the theory suggests. The "turning points" identified for sulfur oxide emissions and SPM emissions were per capita income levels of \$3,670 and \$3,280 respectively. In conclusion, the authors noted that there do seem to be environmental Kuznets curves but only for a specific set of environmental indicators. . Panayiotou (1993), continued the empirical work testing the hypothesis of the EKC. Using cross-section data on nitrous oxide, sulfur oxide emissions, and suspended particulate matter from both developed and developing countries to test the hypothesis. For all of these indicators he failed to reject the hypothesis. He concluded that environmental degradation tends to become worse before it becomes better along a country's development path, in essence validating the EKC conclusion to "grow up and then cleanup". Selden and Song (1994) use similar specifications as the previous study based on a panel data set of 30 countries and focus on Sulfur Dioxide, suspended particulates, nitrogen oxides, and carbon dioxides as the environmental indicators. This study found that the hypothesis of the EKC was confirmed, and the existence of an inverted u-shape relationship existed for all four of the environmental indicators they analyzed. A big noticeable difference in this study is that the discovered "turning points" for each indicator were much higher than previous studies have found. They attributed this finding to the fact that they used aggregate emission data per country, as opposed to urban atmospheric observations.

Most of these previous studies whether or not they confirmed the EKC hypothesis included only a quadratic model specification to test the theory. However, since almost the beginning of EKC studies the empirical existence of an n-shape EKC has been observed. Grossman and Krueger (1995) and Panayotou (1997) find an n-shaped relationship when looking at sulfur dioxide emissions in relation to income per capita. However, for both studies the results were dismissed due to the small number of observations available after the second turning point. Poudel, Paudel and Bhattarai (2009) focused on only carbon dioxide emission levels relationship with income across Latin American Countries and model the relationship as a cubic function and found that the cubic model fit the data better. They concluded that rather than the relationship showing an inverted u-shape it appears in an n-shape. Other studies that concluded the income-pollution relationship is more accurately represented by an n-shape curve. Marsiglio, Ansuategi, Gallastegui (2016) examine the pollution-income relationship in European countries between the years 1995-2009. They also find that the long-run the relationship follows a n-shape curve. These studies suggest that there are two turning points along the pollution-income relationship, the first representing the shift from increasing emission levels to decreasing ones, and the second turning point represents emission levels rising, as income increases, once again.

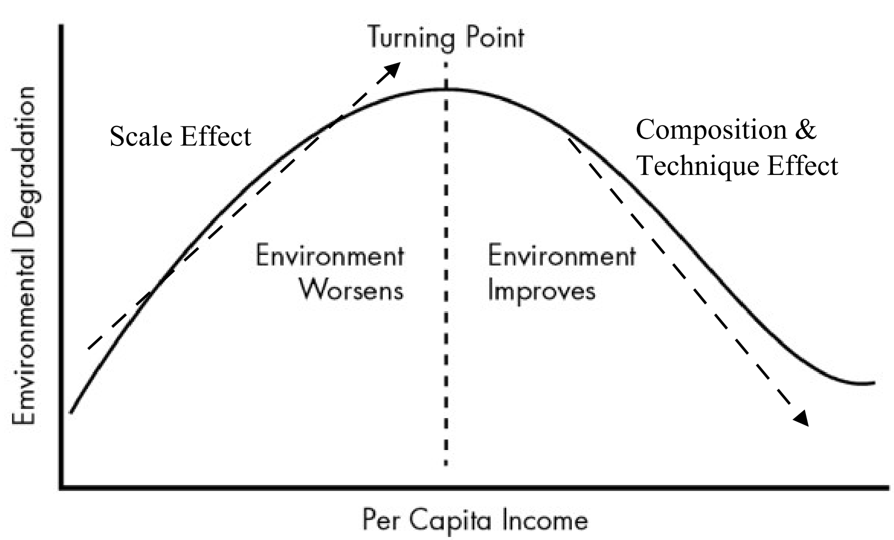
This study will employ both a quadratic model, which is derived from the theoretical model initially set forth by Grossman and Krueger. In addition following previous studies that found the n-shape curve to more significantly represent the pollution-income model, a cubic model will be employed. While the techniques I employ in this study are taking from the previous literature, focusing on the countries that are parties to the Paris Agreement results in new and unique policy recommendations that focus on identifying countries that are least likely to comply with the specific goals of the agreement.

III. Theoretical model

Environmental degradation is an unavoidable by-product of economic activity. Many researchers have attempted to examine this problem through the lens of the Pollution-Income Relationship (PIR). Here pollution is used to measure the level of environmental degradation while income is used as an indicator of economic activity. While this relationship takes several forms the most popular is the Environmental Kuznets Curve Hypothesis. This hypothesis was formed by Grossman and Krueger (1991), when they showed the relationship between environmental health indicators and income could be accurately plotted in an inverse u-shape. This relationship mimics Simon Kuznets hypothesized relationship between equality and income. The inverse u-shape that Grossman and Krueger discovered suggests that as a nation's income rises, initially so will environmental degradation until a certain income level dubbed the "turning point". Following the reaching of said turning point environmental degradation will decrease as income rises.

This EKC relationship is descriptive but behind it are several causative hypotheses. Panayotou (2003) suggested that this turning point occurs because during the initial phases of a nations development there is a significant depletion of natural resources and more importantly in terms of this paper, there is a significant amount of waste and gas emissions accumulating. Then as economic growth continues services, improved technology, and information diffusion lead to reduced environmental damage. Sharik and Bandyopadhyay (1992), DeBruyn et al. (1998), Dinda et al. (2000), and Hettige et al. (2000) all supported the notion that the two main forces directing the pattern of the EKC are structural changes and technical progress. The EKC-curve is shown in Figure 1. The inverted u-shape illustrates that at early stages of development, pollution is generated as a by-product of increasing production and extraction of natural resources, and this is known as the scale effect (Dida, 2004). This scale effect generates the upward trend of the EKC model as a nation shifts from primary production to industrial. It is typically at this industrial production phase that investment is made into information-based industry and service industries start to become dominate in the economy, this is what is known as the composition effect. In addition to a fundamental shift how a country's economy produces at these higher levels of income lead to creating and/or adopting cleaner technology, this is what is known as either the technique or technology effect. The combination of the composition and technique effect can outweigh the scale effect, and this is what generates the downward trend of the EKC curve (Dinda, 2004). However, because these effects are constantly happening within an economy, simultaneously it's entirely possible within the scope of the theory that at a higher income level the scale effect could become greater than the composition & technique effect, which would result in an n-shape curve.

Figure 1



The underlying philosophy often attributed to the EKC-theory is reflected in Beckerman (1992), where he states there is "… clear evidence that, although economic growth usually leads to environmental deterioration in the early stages of the process, in the end, the best and probably the only-way to attain a decent environment in most countries is to become rich" However, if the relationship is better modeled by an n-shape curve, then this notion of growing out of environmental damages is not valid and would not be an effective strategy for any nation working towards reducing emissions.

IV. Empirical Examination

a. Data

The data sample used for the empirical analysis covers every five years from 1975 to 2015 for 194 countries/territories that have signed and ratified the Paris Agreement (Appendix A). Below Table 1 shows the variables being used for the analysis along with a description, unit of measurement, time frame, and if the log was taken for each variable.

Variable Name	**Definition**	**Unit of Measurment**	**Time Frame**	**Logged for Regression?**
GDP	Gross Domestic Product per Capita	Constant 2010 USD	Every 5 years from 1975-2015	yes
Population	Total Country Population	Citizens	Every 5 years from 1975-2015	yes

Trade	Sum of exports and imports	% of GDP	Every 5 years from 1975-2015	no
EduExpen	Government Expenditure on Education	% of GDP	Every 5 years from 1975-2015	no
NO	Nitrous Oxide Emissions	Thousand Metric Tons of CO2 Equivalent per capita	Every 5 years from 1975-2015	yes
Methane	Methane Emissions	kT of CO2 Equivalent per Capita	Every 5 years from 1975-2015	yes
CO2	Total Carbon Dioxide Emissions	Metric tons per capita	Every 5 years from 1975-2015	yes

All Variables Collected From The World Bank DatBank on April 27, 2019

Table 1

To test the true shape of the EKC hypothesis I will employ 3 types of greenhouse gas emissions to indicate the level of environmental degradation in a nation. These include: (1) Nitrous Oxide, (2) Carbon Dioxide, and (3) Methane. This is not the first study to employ these indicators but as the one of the main goals set forth in the Paris Agreement is to reduce greenhouse gas emissions, and these 3 make up the largest percent of greenhouse gas in the atmosphere (EPA). I believe they are the most relevant indicators. Similar to Poudel, Paudel, and Bhattarai (2009), some additional independent variables are included in my model to help control for differences across countries. The first of these control variables is population. This variable is hypothesized to have a positive relationship with emission levels because as population increases there is an increase demand for energy, and a large portion of that demand is fulfilled by fossil fuels, which emit greenhouse gases. Another control variable included is trade as suggested by Allard, Takman, Uddin, Ahmed (2018) trade volume has a positive effect on environmental degradation and emissions because as a country is trades more it results in more emissions either from production or transportation. It is measured by net exports and imports represented as a percentage of GDP. Again, following Poudel et al., I also include an education indicator to control across countries. The indicator they use is illiteracy rate, but I instead used government expenditure on education because a large portion of countries within this data set have an almost inexistent illiteracy rate but still have different levels of education and for a lot of other nations in this set the data was not available. As suggested by Poudel et al. the expected sign of this variable is positive because as a country becomes more educated, they create more and demand more energy.

While these variables included to add additional explanatory power to the model, they are not indicators used to measure the effect of the scale, composition, or technique effect discussed in the theory because the aim of this research is not to explain why the Environmental Kuznets Curve is observed but rather in what form is observed and at what level of income per capita turning points occur for the different greenhouse gasses.

b. Methodology

To test the hypothesis of the form of the EKC, I followed the approach and advice of previous researchers discussed in the earlier portions of this paper most specifically Poudel, Paudel, and Bhattarai. While modifying came from the suggestions of Armeanu, Vintilā, Andrei, Gherghina, Drāgoi, Teodor (2018). Ultimately, the models I derived show the long-run relationship between emission levels, income per capita, trade, population, and education expenditure. These models are as follows:

(1) $Emissions_{it} = \alpha_0 + \boldsymbol{\beta_1 GDP_{it} + \beta_2 GDP^2_{it}} + \beta_3 Pop\_ln_{it} + \beta_4 Trade_{it} + \beta_5 EduExpen_{it} + \varepsilon_1$

(2) $Emissions_{it} = \alpha_0 + \boldsymbol{\beta_1 GDP_{it} + \beta_2 GDP^2_{it}} + \boldsymbol{\beta_3 GDP^3_{it}} + \beta_4 Pop\_ln_{it} + \beta_5 Trade_{it} + \beta_6 EduExpen_{it} + \varepsilon_1$

Where:

Emissions = Total Greenhouse gas emissions, Methane emission, Nitrous Oxide emissions, Hydrofluorocarbon, perfluorocarbons, and sulfur hexafluoride emissions (which are grouped under other greenhouse gases), CO2 emissions, and CO_2 emissions by sector. (All expressed in natural log)

GDP, GDP^2, and GDP^3 = Per capita income (expressed in natural log)

Pop_ln = Total Population (expressed in natural log)

Trade = Net Exports and Imports represented as a % of GDP

EducExpen = Government expenditure as a % of GDP

Model (1) is a quadratic specification of the pollution-income model and the EKC theory predicts that the fixed effect regression will result in a β_1 that is positive and significant and a β_2 that is negative and significant. This result would mean that when plotted an inverted u-shape, like the one shown in Figure 1, would be present. The second model is the cubic specification and if the pollution income model is more significant in this model that means the relationship is better modeled in the n-shape curve found by some economist earlier.

To analyze the relationship across all the countries and years in my data set I will employ a two-way fixed effects panel regression for both model (1) and (2). The results of this analysis can be found in the next section.

V. Results

The results that come from the fixed effects panel regressions, those results are in table 4 and 5. Table 4 are the results for the quadratic model (1) and show that for both carbon dioxide and nitrous oxide the income-pollution portion of the model (GDP + GDP^2) is significant and the signs of the coefficients match the theory. This suggests that the relationship between income and carbon dioxide and nitrous oxide emissions can be presented by an inverted u-shape curve.

Table 2

	Nitrous Oxide	Methane	CO2
GDP	**1.291217***	**0.009199**	**1.736392***
	4.87	*0.04*	*6.53*
GDP sq.	**-0.05721****	**0.012847**	**-0.05723****
	-3.46	*0.96*	*-3.45*
Pop_ln	**1.050273***	**0.883965***	**1.484323***
	9.22	*0.883965*	*12.98*
Trade	**0.002044****	**0.001224****	**0.000823**
	3.60	*2.68*	*1.44*
EduExpen	**-0.00146**	**-0.00283**	**0.028404****
	-0.15	*-0.36*	*2.88*
R-sq	.9899	.9934	.9941
F Value	59.26*	70.29	31.19*
Intercept	-15.0447*	-6.08222*	-24.5114

*denotes significance at 99% levels
**denotes significance at 95% levels
***denotes significance at 90% levels
Bolded numbers represent the Parameter Estimate
Italicized numbers represent t Value

However, it is still possible that a cubic model would be more significant and fit the data better, so to test this I ran my second model specification, model (2). The results in table 5, show that the pollution-income part of the model becomes insignificant for carbon dioxide and nitrous oxide but for methane becomes significant when it wasn't for the first model. This suggests that modeling the income-pollution relationship for carbon and nitrous dioxide is best done in a quadratic specification, but methane is better fit by a cubic specification.

As for the other variables used in my models as controls, when significant their signs followed what theory suggested they should. For population, it was always significant and positive, meaning that more people lead to higher demand for energy which often is supplied by greenhouse gas emitting methods. Education, when significant also showed a positive relationship with emission levels, showing that emission levels rise as more people are educated and start creating products and industries. Lastly trade when significant was also positive, and emission rise when trade levels increase, either due to higher production levels or more transportation, or both.

	Nitrous Oxide	Methane	CO2
GDP	**0.108688**	**1.85569*** **	**-1.37064**
	0.08	*1.75*	*-1.04*
GDP_sq	**0.08598**	**-0.21074*** **	**0.31899** **
	0.55	*-1.67*	*2.03*
GDP_cub	**-0.00565**	**0.008829*** **	**-0.01486** **
	-0.91	*0.0761*	*-2.41*
Pop_ln	**1.039066***	**0.901465***	**1.454878***
	9.06	*9.80*	*12.73*
Trade	**0.002041** **	**0.001229** **	**0.00815**
	3.59	*2.69*	*1.44*
EducExpen	**-0.00182**	**-0.00227**	**0.027453** **
	-0.19	*-0.29*	*2.79*
R-sq	0.9899	0.9934	.9942
F Value	58.63*	68.81*	31.58*
Intercept	-11.6541 **	-11.3765**	-15.6029**
*denotes significance at 99% levels			
**denotes significance at 95% levels			
***denotes significance at 90% levels			
Bolded numbers represent the Parameter Estimate			
Italicized numbers represent t value			

The next step of this research is to try and graph the models to find the turning point level of GDP per capita for each emission. To do this I used an online graphing calculator software and entered my models using the coefficients found from the regression. The resulting graphs are laid out below in figures 1, 2, and 3.

Figure 2

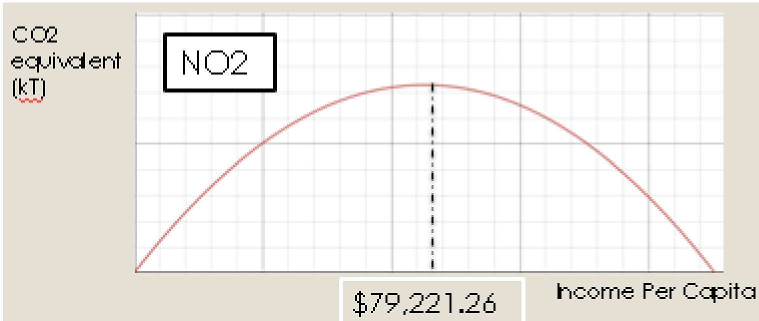


Figure 3

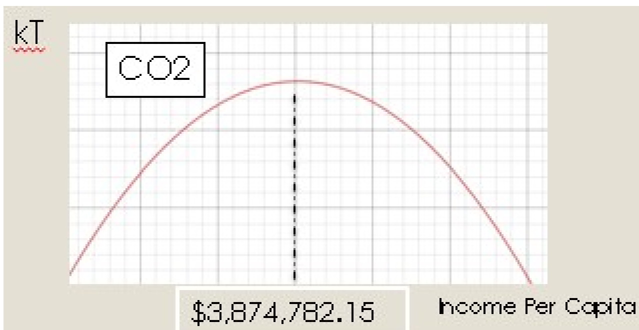
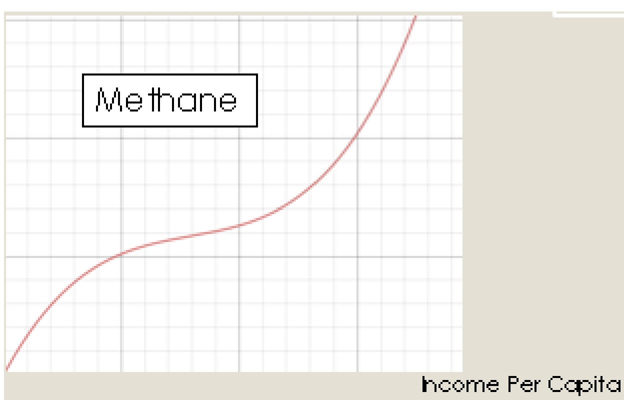


Figure 4



For methane the curve is a flattened n-shape curve without any turning points. Instead the rate at which methane levels increase changes as income per capita increase but do not show any points of decreasing. Nitrogen oxide as can be observed in figure 1, shows the EKC inverted u-shape curve and the calculated turning point was found to be $79,221.26. Carbon dioxide shows the similar u-shape curve, but the turning point found for carbon dioxide is $3,874,782.15. As these levels are measured in per capita GDP they are very overstated. This is a trend that happened to several other researchers as noted by Dinda (2004). The reason for the overstatement in income levels is likely due to the lack of explanatory variables that represent the technique and composition effect. If those variables were to be added the turning points would likely be shifted to the left. The shape of the curve and the turning points found in this study are more representative of what the EKC curve would be if countries never learned new things and better techniques or developed new renewable techniques. The good news is most every country in some way have the composition and technique effect happening within their economies even if accidental, meaning that the turning points for these gas emissions are much lower and likely more attainable.

VI. Conclusion

Based on the results the for carbon dioxide and nitrous oxide the original theory of the EKC seems to hold up and the modified n-shape theory is more valid for methane. However, despite getting results validating the theory the overstatement of the turning point is a problem because the results aren't usable in terms of forming policy implications. I would suggest a more appropriate approach to this kind of study is to add explanatory variables that represent the scale, composition, and technique effect. This would cause the EKC to shrink to a point where the turning points would be more accurate and then it would be possible to identify which countries had economic incentives to comply to the goals of the Paris Agreements and which weren't. Knowing this would make it easier to know where pressure or assistance would be needed to reach the goals of the agreement. Based on the turning points found in this study no country has economic incentive to comply with the agreement and in addition they are unlikely to reach their turning point naturally without taking specific actions that would shrink the curve. As for methane without intervention the level of emission will continue to increase as a country's income does. Knowing the different relationships between income and the different greenhouse gasses is important because since they take different forms policies should be different for each to be most effective.

Future studies should focus on the underlying causes of the Kuznets curve and their relationship with emission levels rather than just examining if the curve exist. Studies focusing on the underlying causes are likely to result in turning points that yield realistic policy implications that are more detailed than, the ones provided from this study.

References

Armeanu, D., Vintilă, G., Andrei, J. V., Gherghina, Ş C., Drăgoi, M. C., & Teodor, C. (2018, 05). Exploring the link between environmental pollution and economic growth in EU-28 countries: Is there an environmental Kuznets curve? *Plos One, 13*(5). doi:10.1371/journal.pone.0195708

Costantini, V., & Martini, C. (2006). A Modified Environmental Kuznets Curve for Sustainable Development Assessment Using Panel Data. *SSRN Electronic Journal*. doi:10.2139/ssrn.951457

Easterlin, R. A., & Angelescu, L. (2007). Modern Economic Growth and Quality of Life: Cross Sectional and Time Series Evidence. *SSRN Electronic Journal*. doi:10.2139/ssrn.980354

Energy for Economic Growth, Energy Vision Update 2012. (n.d.). Retrieved from http://reports.weforum.org/energy-for-economic-growth-energy-vision-update-2012/

Global Greenhouse Gas Emissions Data. (2017, April 13). Retrieved from https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

Grossman, G., & Krueger, A. (1991, 11). Environmental Impacts of a North American Free Trade Agreement. doi:10.3386/w3914

Kaika, D., & Zervas, E. (2013, 11). The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO2 emissions case. *Energy Policy, 62*, 1392-1402. doi:10.1016/j.enpol.2013.07.131

Marzio Galeotti, Yana Rubashkina, Silvia Salini, Elena Verdolini. (2018). *Environmental policy performance and its determinants: Application of a three-level random intercept model, Energy Policy*. Volume 114. Pages 134-144, ISSN 0301-4215. https://doi.org/10.1016/j.enpol.2017.11.053.

Moutinho, V., Varum, C., & Madaleno, M. (2017, 07). How economic growth affects emissions? An investigation of the environmental Kuznets curve in Portuguese and Spanish economic activity sectors. *Energy Policy, 106*, 326-344. doi:10.1016/j.enpol.2017.03.069

Poudel, B. N., Paudel, K. P., & Bhattarai, K. (2009, 04). Searching for an Environmental Kuznets Curve in Carbon Dioxide Pollutant in Latin American Countries. *Journal of Agricultural and Applied Economics, 41*(01), 13-27. doi:10.1017/s1074070800002522

Selden, T. M., & Song, D. (1994, 09). Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions? *Journal of Environmental Economics and Management, 27*(2), 147-162. doi:10.1006/jeem.1994.1031

Shafik, Nemat; Bandyopadhyay, Sushenjit; Shafik, Nemat*Bandyopadhyay, Sushenjit. 1992. *Economic growth and environmental quality : time series and cross-country evidence (English)*. Policy, research working papers ; no. WPS 904. World development report. Washington, DC: World Bank.

What is the Paris Agreement? (n.d.). Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

World Bank Open Data. (n.d.). Retrieved from https://data.worldbank.org/

https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

MOOMAW, W., & UNRUH, G. (1997). Are environmental Kuznets curves misleading us? The case of CO2 emissions. *Environment and Development Economics, 2*(4), 451-463. doi:10.1017/S1355770X97000247

Allard, A., Takman, J., Uddin, G. S., & Ahmed, A. (2017). The N-shaped environmental Kuznets curve: an empirical evaluation using a panel quantile regression approach. *Environmental science and pollution research international*, *25*(6), 5848–5861. doi:10.1007/s11356-017-0907-0

Appendix A: Countries who signed Paris Agreement

Participants

Afghanistan	Cabo Verde	Equatorial Guinea
Albania	Cambodia	Eritrea
Algeria	Cameroon	Estonia
Andorra	Canada	Eswatini
Angola	Central African Republic	Ethiopia
Antigua and Barbuda	Chad	European Union
Argentina	Chile	Fiji
Armenia	China	Finland
Australia	Colombia	France
Austria	Comoros	Gabon
Azerbaijan	Congo	Gambia
Bahamas	Cook Islands	Georgia
Bahrain	Costa Rica	Germany
Bangladesh	Côte d'Ivoire	Ghana
Barbados	Croatia	Greece
Belarus	Cuba	Grenada
Belgium	Cyprus	Guatemala
Belize	Czech Republic	Guinea
Benin	Democratic People's Republic of Korea	Guinea-Bissau
Bhutan	Democratic Republic of the Congo	Guyana
Bolivia (Plurinational State of)	Denmark [1]	Haiti
Bosnia and Herzegovina	Djibouti	Honduras
Botswana	Dominica	Hungary
Brazil	Dominican Republic	Iceland
Brunei Darussalam	Ecuador	India
Bulgaria	Egypt	Indonesia
Burkina Faso	El Salvador	Iran (Islamic Republic of)
Iraq	Mexico	Republic of Korea
Ireland	Micronesia (Federated States of)	Republic of Moldova
Israel	Monaco	Romania
Italy	Mongolia	Russian Federation
Jamaica	Montenegro	Rwanda

Japan	Morocco	Samoa
Jordan	Mozambique	San Marino
Kazakhstan	Myanmar	Sao Tome and Principe
Kenya	Namibia	Saudi Arabia
Kiribati	Nauru	Senegal
Kuwait	Nepal	Serbia
Kyrgyzstan	Netherlands [2]	Seychelles
Lao People's Democratic Republic	New Zealand [3]	Sierra Leone
Latvia	Nicaragua	Singapore
Lebanon	Niger	Slovakia
Lesotho	Nigeria	Slovenia
Liberia	Niue	Solomon Islands
Libya	North Macedonia	Somalia
Liechtenstein	Norway	South Africa
Lithuania	Oman	South Sudan
Luxembourg	Pakistan	Spain
Madagascar	Palau	Sri Lanka
Malawi	Panama	St. Kitts and Nevis
Malaysia	Papua New Guinea	St. Lucia
Maldives	Paraguay	St. Vincent and the Grenadines
Mali	Peru	State of Palestine
Malta	Philippines	Sudan
Marshall Islands	Poland	Suriname
Mauritania	Portugal	Sweden
Mauritius	Qatar	Switzerland
Syrian Arab Republic		
Tajikistan		
Thailand		
Timor-Leste		
Togo		
Tonga		
Trinidad and Tobago		

Tunisia

Turkey

Turkmenistan

Tuvalu

Uganda

Ukraine

United Arab Emirates

United Kingdom of Great Britain and Northern Ireland

United Republic of Tanzania

United States of America

Uruguay

Uzbekistan

Vanuatu

Venezuela (Bolivarian Republic of)

Viet Nam

Yemen

Zambia

Zimbabwe

From: United Nation Treaty Collection

TWO WAY FIXED EFFECTS MODEL CODE:

```
data haley;
set work.one;
rename GDP_per_Capita=GDP;
rename CO2_emissions=CO2;
rename Government_expenditure_on_educ=EduExpen;
rename Other_greenhouse_gas_emissions=OGHG;
rename Total_greenhouse_gas_emissions=GHG;
rename Nitrous_oxide_emissions=NO;
rename Methane_emissions=Methane;
run;


data work.logs;
set work.haley;
if Country = "ARE" then delete;
if Country = "ATG" then delete;
if Country = "BHR" then delete;
if Country = "BIH" then delete;
if Country = "COM" then delete;
if COuntry = "CPV" then delete;
if country = "DJI" then delete;
```

```
if country= "DMA" then delete;
if country = "ERI" then delete;
if country = "ETH" then delete;
if country = "GNQ" then delete;
if country = "GRD" then delete;
if country = "HTI" then delete;
if country = "JOR" then delete;
if country = "KIR" then delete;
if country = "KNA" then delete;
if country = "LBR" then delete;
if country = "LBY" then delete;
if country = "LCA" then delete;
if country = "LSO" then delete;
if country = "MDV" then delete;
if country = "MMR" then delete;
if country = "PNG" then delete;
if country = "STP" then delete;
if country = "SUR" then delete;
if country = "TON" then delete;
if country = "TKM" then delete;
if country = "TTO" then delete;
if country = "TVO" then delete;
if country = "TUV" then delete;
if country = "UZB" then delete;
if country = "WSM" then delete;
if country = "YEM" then delete;
if country = "LIC" then delete;
if country = "MIC" then delete;
if country ="HIC" then delete;
if GDP <=0 then delete;
if CO2 <=0 then delete;
if OGHG <=0 then delete;
if Population <=0 then delete;
if GHG <=0 then delete;
if NO <=0 then delete;
if Methane<=0 then delete;
GDP_ln=log(GDP);
GDPsq_ln=log(GDP)*log(GDP);
GDPcb_ln=log(GDP)*log(GDP)*log(GDP);
CO2_ln=log(CO2);
OGHG_ln=log(OGHG);
Pop_ln=log(Population);
GHG_ln=log(GHG);
NO_ln=log(NO);
Methane_ln=log(Methane);
run;

proc sort data =work.logs;
by country Time;
run;
proc panel data=work.logs;
id Country Time;
model NO_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixtwo;
model NO_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixtwo;
model Methane_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixtwo;
model Methane_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixtwo;
model GHG_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixtwo;
```

```
model GHG_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixtwo;
model OGHG_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixtwo;
model OGHG_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixtwo;
model CO2_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixtwo;
model CO2_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixtwo;
run;


data haley;
set work.one;
rename GDP_per_Capita=GDP;
rename CO2_emissions=CO2;
rename Government_expenditure_on_educ=EduExpen;
rename Other_greenhouse_gas_emissions=OGHG;
rename Total_greenhouse_gas_emissions=GHG;
rename Nitrous_oxide_emissions=NO;
rename Methane_emissions=Methane;
run;
```

ONE WAY FIXED EFFECTS MODEL CODE

```
data work.logs;
set work.haley;
if Country = "ARE" then delete;
if Country = "ATG" then delete;
if Country = "BHR" then delete;
if Country = "BIH" then delete;
if Country = "COM" then delete;
if COuntry = "CPV" then delete;
if country = "DJI" then delete;
if country= "DMA" then delete;
if country = "ERI" then delete;
if country = "ETH" then delete;
if country = "GNQ" then delete;
if country = "GRD" then delete;
if country = "HTI" then delete;
if country = "JOR" then delete;
if country = "KIR" then delete;
if country = "KNA" then delete;
if country = "LBR" then delete;
if country = "LBY" then delete;
if country = "LCA" then delete;
if country = "LSO" then delete;
if country = "MDV" then delete;
if country = "MMR" then delete;
if country = "PNG" then delete;
if country = "STP" then delete;
if country = "SUR" then delete;
if country = "TON" then delete;
if country = "TKM" then delete;
if country = "TTO" then delete;
if country = "TVO" then delete;
if country = "TUV" then delete;
if country = "UZB" then delete;
if country = "WSM" then delete;
if country = "YEM" then delete;
```

```
if country = "LIC" then delete;
if country = "MIC" then delete;
if country ="HIC" then delete;
if GDP <=0 then delete;
if CO2 <=0 then delete;
if OGHG <=0 then delete;
if Population <=0 then delete;
if GHG <=0 then delete;
if NO <=0 then delete;
if Methane<=0 then delete;
GDP_ln=log(GDP);
GDPsq_ln=log(GDP)*log(GDP);
GDPcb_ln=log(GDP)*log(GDP)*log(GDP);
CO2_ln=log(CO2);
OGHG_ln=log(OGHG);
Pop_ln=log(Population);
GHG_ln=log(GHG);
NO_ln=log(NO);
Methane_ln=log(Methane);
run;

proc sort data =work.logs;
by country ;
run;
proc panel data=work.logs;
id Country Time;
model NO_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixone;
model NO_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixone;
model Methane_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixone;
model Methane_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixone;
model GHG_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixone;
model GHG_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixone;
model OGHG_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixone;
model OGHG_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixone;
model CO2_ln= GDP_ln GDPsq_ln pop_ln Trade EduExpen / fixone;
model CO2_ln= GDP_ln GDPsq_ln GDPcb_ln pop_ln Trade EduExpen / fixone;
run;
```