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# Emission, Education, and Politics: An Empirical Study of the Carbon Dioxide and Methane Environmental Kuznets Curve

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## Abstract

This study will estimate carbon dioxide and methane emissions of 181 countries in 2012 through the use of a quadratic function of per capita GDP. Several variables will be used as controls; with GDP per capita, mean years of education, and government regime being the most important. This study estimates the emissions of carbon dioxide and methane because the EPA states that these two gasses account for roughly 92% of the worlds greenhouse gasses, thus making it vital that we have a strong understanding of both gases. Also, no literature known to the author has looked into the evidence of a methane EKC making this work all the more important. This study will be sectioned as follows, a review of past literature will be made in section II, further discussion of the theory will be given in section III, the data used in the study will be evaluated in section IV, the model for this study will be established in section V, descriptive statistics and results will be deliberated in section VI, and concluding remarks will be presented in section VII.

# Emission, Education, and Politics: An Empirical Study of the Carbon Dioxide and Methane Environmental Kuznets Curve

## Cody Williamson

### I. Introduction

It is undeniable that humanity has had a great impact on the natural world that we rely on for survival. Since the industrial revolution in the late 18th and into the 19th century, large amounts of gasses have continued to be emitted which have led to changes and implications that at first were unforeseen. Over the last few decades though, a large amount of literature has been put forth to better understand the consequences of the emissions released into the atmosphere with a hope to combat the damage that has been done, and will be done through our continued industrial activities. Currently the United States' Environmental Protection Agency (EPA) has identified four types or categories of gases that are referred to as greenhouse gasses. These gases have the ability to slow the escape of heat in the atmosphere and therefore are thought to have the largest impact on current climate changes.

In this area of study, economics has made a great contribution through the continued research of the relationship between economic activity and the externalities produced from them. One prominent, yet highly debated hypothesis is that of the environmental Kuznets curve. First proposed in the late 1990's, an inverted U-shape relationship was found between per capita emissions and per capita income, which resembles the relationship between the wealth of a nation and income inequality proposed by Simon Kuznets in the 1950's. Since the environmental Kuznets curve (EKC) hypothesis was first brought forth, further evidence for its existence has been rather mixed and inconclusive. The current literature varies greatly in model structure, data, reference countries, pollutant observed, and purpose of the studies. The studies cited in this current paper can generally be compiled into three different focuses. The first grouping focuses solely on the identification of an EKC through the use of different empirical techniques (Yaduma 2015, Apergis et al 2016). The second grouping looks to find evidence of an EKC but also looks to see if certain factors will affect the existence of a curve (Franklin and Ruth 2012, Yin et al 2015, Marsiglio et al 2016). While the last looks to define, or estimate the tipping point of any existing curve (Bernard et al 2015). Thus, the first looks to see if a certain model will derive a curve, the second looks to see if certain outside factors will affect the existence of the curve, while the third tries to perceive if there is a tangible turning point for existing curves. My paper would fall into the second category due to its focus on understanding the influences that education and government regimes would have on an EKC. These two variables seem to be largely absent in current literature, therefore my research attempts to fill this void. The two main questions that will be addressed in this study are whether there is an EKC evident in the countries that emit both carbon dioxide and methane? And second, if there is an EKC, will the education of their people and the government structure affect the shape of the curve?

This study will estimate carbon dioxide and methane emissions of 181 countries in 2012 through the use of a quadratic function of per capita GDP. Several variables will be used as controls; with GDP per capita, mean years of education, and government regime being the most important. This study estimates the emissions of carbon dioxide and methane because the EPA states that these two gasses account for roughly 92% of the worlds greenhouse gasses, thus making it vital that we have a strong understanding of both gases. Also, no literature known to the author

has looked into the evidence of a methane EKC making this work all the more important. This study will be sectioned as follows, a review of past literature will be made in section II, further discussion of the theory will be given in section III, the data used in the study will be evaluated in section IV, the model for this study will be established in section V, descriptive statistics and results will be deliberated in section VI, and concluding remarks will be presented in section VII.

## II. Literature Review

The roots of the environmental Kuznets curve can be traced back to the early 1990's with the publication of several key papers. Some pivotal findings have come from papers such as Shafik and Bandyopadhyay (1992), Berkerman (1992), World Bank development report (1992), Panayotou (1993) who is attributed with coining the term environmental Kuznets curve[1], Holtz-Eakin and Selden (1995), and Grossman and Krueger (1993) (1995). With this in mind it is important to note that many writings attribute Grossman and Krueger's 1993 paper, which was first written in 1991 but not published until 1993, as the work that paved the way for the empirical study of the early EKC hypothesis; while their 1995 paper popularized it even further. Grossman and Krueger (1995) looks at the national income of a country, measured as GDP per capita, and four environmental indicators to empirically understand the relationship between them. These four indicators are urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins with heavy metals. Their data showed that there was no indication of a continuous degradation of the environment with the ongoing growth of an economy, but instead they found signs of a relationship where economic growth brings degradation initially and then improves after a certain period; thus, an inverted U-shaped curve (Krueger 1995). The other big finding of their work was that the peak of the curves is expected to occur sometime before or near the time a countries GDP per capita reached $8,000 (1985 dollars). Their findings are largely consistent with their contemporaries and though their estimated turning points are slightly higher. Grossman and Krueger's (1995) work was extremely influential for its time and it continues to provide a good starting point for modern works.

In more modern literature, the results and evidence for the existence of an EKC have been rather inconclusive. Some studies have found evidence of an EKC for only certain countries and not others, or for only a certain type of pollutant. These inconsistencies have by no means discouraged EKC research. In order to get a better understanding, three focuses were identified in the literature referenced for this current study, and the papers were then separated in these three areas of thought.

The first area of recent EKC research can generally be described as works that put a focus on new or alternative models or techniques to estimate the EKC. One of the techniques that is utilized is the quantile fixed effects technique to capture heterogeneity among the countries studied. This revealed evidence for the existence of an EKC for specific regions or groups, but not one that can fit the entire world. Evidence from this model also revealed that conventional fixed effect models may portray a flawed representation of the income-emissions nexus (Yaduma 2015). Another evident technique is the use of both panel and time series based approaches to estimate an EKC for a set number of countries (Apergis 2016). This approach found that 12 out of 15 countries studied displayed evidence of an EKC for carbon dioxide emissions.

[1] Dinda, S. (2004). Environmental kuznets curve hypothesis: A survey. *Ecological Economics, 49*(4), 431-455. doi:http://dx.doi.org/10.1016/j.ecolecon.2004.02.011

The second area of recent research was created around studies that sought to understand the effects or impacts that outside variables have on the relationship between income and pollutants. Some of these outside variables include population (Franklin 2012), economic structure changes (Franklin 2012, Marsiglio 2016), environmental regulation, and technical progress (Yin 2015). All four variables are significant and seem to have an effect on the relationship between country income and pollution levels. The significance of these variables aids in expanding the understanding of the EKC theory.

The last area was created around papers that focused on identifying a certain aspect, such as inflection points, of an EKC. There seems to be little research done on this in the last decade or so. There is only one paper known to the author at this time that has looked into this subject matter, this work was done in 2015 by Jean-Thomas Bernard and associates. What they found was that although the tipping points could be estimated with some unreliability, the numbers were found to be economically implausible.

## III. Theory

The driving theory behind the environmental Kuznets curve is that as countries develop and increase their wealth, their emissions first increase but then decrease after a certain level of income is reached. Based on prior research, it is believed that as a country starts to develop, they become more industrialized; resulting in increasing emission outputs. Then, as their wealth increases, there are changes in the economic structure, which eventually promote cleaner industrial practices and service oriented industries. For example, new agricultural based nations start in a pre-industrial economic system with low emissions. Then as they start to develop and increase the production of non-agricultural commodities, they move into a high emissions industrial structure. Finally, after a certain level of wealth is achieved then that nation's economy will transform into a cleaner, service oriented economy with decreasing levels of emissions over time. However, some argue that structural changes on their own do not cause a change in the slope of the EKC. Through a combined effort of these changes and other factors such as environmental awareness, enforcement of environmental regulations, better technology, and higher environmental expenditures lead to a plateau and eventual declination of the EKC's slope (Dinda 2004, Franklin 2012, Yin 2015, Marsiglio 2016).

The purpose of this paper is to research the influence that education levels and government regime have on the formation of the EKC. Education levels and government regimes both affect the environmental awareness of a country as well as the environmental regulations that are put in places. As the education levels of a country improve, it is believed that environmental awareness should increase and thus decrease harmful emissions through the work of individuals and law makers. Additionally, higher education levels produce higher levels of clean and efficient technologies, which would also negate a portion of emissions. Therefore, based on the theory presented on the environmental Kuznets curve hypothesis, it is believed that an increase in a country's level of education will, ceteris paribus, shift the environmental Kuznets curve downwards due to decreases in pollution. On the other hand, it is uncertain how the different government regimes will affect the curve due to the difficulty of determining which governmental structure would be more successful in implementing environmental regulations when solely observing their ideology.

## IV. Data

The data collected for my analysis will come from three databases. The first is the World Development Indicators. This database is maintained by the World Bank and has 1440 data series for 264 countries. This database provides the information for almost all of the data points in this study. The second is the Human Development Report, which is supported by the United Nations. This report analyzes information such as education level, life expectancies, and a nations GNI, all of which are used to calculate the Human Development Index. This work will be utilizing the 2012 data for the values of mean years of education, which is the main measurement for education in this study. The last database is the CIA World Fact Book. Run by the Central Intelligence Agency, this site contains a plethora of information; however, I will only be using it for my government regime variables. All three databases are run by reputable sources and are appropriate for the research that is being conducted. However, there are a few variables that have a number of omitted values which may potentially have a negative effect on the study overall. The problem of omission will be dealt with by removing any obverted countries that are lacking data when these variables are included in the regression.

Cross-sectional data will be utilized in this study from the year 2012. This year is used because it is the latest year with the most complete data set. This study will be observing 181 countries all ranging from development status to geological location. These countries were chosen based on the availability of data for GDP, carbon dioxide emissions, and methane emissions due to the importance of these variables to the overall study.

## V. Empirical Model

In order to test for both carbon dioxide and methane, several models will be employed. Though some of the independent variables were derived from past studies, others are new to this type of study and were added because they were believed to have some impact on the estimation of the emissions. GDP, $GDP^2$, mean years of education, and the five variables for government regime are the main focus of this study; while all other independent variables are control variables. The first equation predicts carbon dioxide emissions as a function of these independent variables:

$$CO_2 = +\beta_1 GDP + \beta_2 GDP^2 + \beta_3 MYOS + \beta_4 CM + \beta_5 PAR + \beta_6 PR + \beta_7 CS + \beta_8 OT + \beta_9 IND + \beta_{10} AGR + \beta_{11} EPC + \beta_{12} EPNG + \beta_{13} EPO + \mu$$

And the second equation will estimate per capita methane emissions as a function of the same variables.

$$CH_4 = \alpha + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 MYOS + \beta_4 CM + \beta_5 PAR + \beta_6 PR + \beta_7 CS + \beta_8 OT + \beta_9 IND + \beta_{10} AGR + \beta_{11} EPC + \beta_{12} EPNG + \beta_{13} EPO + \mu$$

The independent variables GDP and $GDP^2$ measure the gross domestic product in per capita 2010 constant US dollars. This unit of currency allows cross country comparison without having to worry about exchange rates among the different units of currency. If there is evidence for an environmental Kuznets curve in the data that is utilized in this study, the coefficient for GDP will be positive and the coefficient for $GDP^2$ will be negative. It is the sign of these two variables that will give the curve the inverted U shape. Therefore, if these signs are present, a EKC will be evident.

**Table 1: Description of Variables**

| Variables | Long Definitions | Expected Sign |
|---|---|---|
| $CO_2$ | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Measured in metric tons per capita | |
| $NH_4$ | Methane emissions are those stemming from human activities such as agriculture and from industrial methane production. Measured in metric tons of $CO_2$ equivalent per capita | |
| GDP | GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 U.S. dollars. | + |
| $GDP^2$ | Squared measure of GDP | - |
| MYOS | Mean year of school. This represents the average years that the population of a country has attended an educational institution. | - |
| CM | Constitutional monarchy. | NA |
| PAR | Parliamentary system. | NA |
| PR | Presidential republic. | NA |
| CS | Communist state. | NA |
| OT | Other; nations with the governmental structure designated as a theocracy or in transition. | NA |
| IND | It comprises value added in mining, manufacturing, construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. Values are calculated as a percentage of GDP | + |
| AGR | Agriculture includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. Values are calculated as a percentage of GDP. | + |
| EPC | Sources of electricity refer to the inputs used to generate electricity. Coal refers to all coal and brown coal, both primary (including hard coal and lignite-brown coal) and derived fuels (including patent fuel, coke oven coke, gas coke, coke oven gas, and blast furnace gas). Peat is also included in this category. | + |
| EPNG | Sources of electricity refer to the inputs used to generate electricity. Gas refers to natural gas but excludes natural gas liquids. | + |
| EPO | Sources of electricity refer to the inputs used to generate electricity. Oil refers to crude oil and petroleum products. | + |

MYOS is the mean years of schooling for persons 25 years and older. This variable is one of the main focuses of the paper and will be the single variable used to test the significance of the education levels of the countries observed. If the hypothesis for this study is correct, then the sign displayed for the variable should be negative. This prediction is based on the theory that was presented earlier in the study. As education increases, citizens should become more aware of their externalities and produce lower emissions. Higher education levels should also increase levels of clean and efficient technologies, which would lead to fewer emissions.

The five variables (CM, PAR, PR, CS and OT) are all dummy variables that will be used to measure the government regime portion of this paper's hypothesis. The governing style "absolute monarchy" will be the reference group for the dummy variables. CM is constitutional monarchy, PAR is parliamentary system, PR is presidential republic, CS is communist state, and OT is other. The variable designated as other is added to this study because there were a few countries in the CIA data base that were listed as "in transition" and one country that was said to be a "theocracy". Therefore, this variable will represent those nations. Based on the lack of theory for these variables, it is uncertain which sign the coefficients will display. Regardless, these variables are still a vital part of this study even though there is no theoretically derived hypothesis for their signs.

Next, IND will be a measurement of industry. This variable will be measured as a percentage of GDP, which was the suggested measure used by Bernard (2015). This variable will show the portion of GDP in manufacturing across several different sectors. The coefficient sign for industry is believed to be positive because the production of goods almost always utilizes machinery. Industrial activities will continue to emit gasses like carbon dioxide and methane despite the level of technology

AGR represents agriculture value added as a percentage of GDP. Based on the theory, it is believed that the coefficient for the agriculture variable will display a positive sign because, countries with higher levels of agriculture should be producing more methane gas. Coincidentally, heavy farm equipment produces carbon dioxide emissions as well.

The next three variables are measures for the percentages of energy produced from fossil fuels. EPC denotes the percentage of energy produced by coal, EPNG denotes the percentage of energy produced by natural gas, and EPO denotes the percentage of energy produced by oil. It is feasible and appropriate to measure these three units as one; however, Bernard 2015 mentions that "coal has twice the $CO_2$ emissions related to natural gas per unit of energy and oil products are half way in between" (Bernard 291) and the EPA cites that methane is the primary component of natural gas. Therefore, it is best to include each variable to see the individual impact exerted on the dependent variable. It is believed that the higher the percentage of these three sources, the more carbon dioxide and methane will be emitted. Therefore, the signs of all three coefficients should be positive. Table 1 below displays the expected sign of each variable and a longer definition of each.

## VI. Descriptive Statistics and Results

The empirical work done in this study is the foundation to test the hypothesis that was proposed in this paper. Alongside this, descriptive statistics will be used to set the stage for the regression analysis and to introduce the variables used in the analysis. This section will first present the descriptive statistics followed by a discussion of the regression results.

### VI.A. Descriptive Statistics

The results of the descriptive statics can be seen below in Table 2. In Table 2, all 181 countries were split up into three different levels of income low, medium and high. This split was created by first ordering the countries by their level of GDP per capita, then dividing them into three groups. High income accounts for 60 countries, medium income 61 countries, and low income 60 countries. The numbers for the numeric variables are the calculated averages for the countries in each level of income, while the numbers for the dummy variables (Absolute monarchy, Constitutional monarchy, Parliament, Presidential republic, Communist, and Other) are a count of the number of countries under that particular governing structure.

**Table 2: Descriptive Statistics**

| Variables | Low income | Medium income | High Income |
|---|---|---|---|
| Carbon Dioxide (kt) | .604 | 3.755 | 10.106 |
| Methane (kt $CO_2$ equivalents) | .00119 | .00115 | .00230 |
| GDP per Capita in Thousands of Dollars | 1.105 | 5.590 | 33.606 |
| Mean Years of Education | 4.933 | 8.719 | 10.807 |
| Absolute Monarchy | 0 | 1 | 5 |
| Constitutional Monarchy | 5 | 7 | 16 |
| Parliament | 7 | 17 | 21 |
| Presidential Republic | 45 | 30 | 19 |
| Communist | 2 | 2 | 1 |
| Other | 1 | 2 | 1 |
| Industry, value added (% of GDP) | 24.21% | 30.47% | 32.45% |
| Agriculture, value added (% of GDP) | 25.88% | 9.66% | 2.52% |
| Coal Electricity | 8% | 21.43% | 18.88% |
| Natural Gas Electricity | 21.88% | 27.11% | 33.10% |
| Oil Electricity | 22.54% | 19.80% | 10.43% |

When looking at Table 2, there does not appear to be clear evidence of an environmental Kuznets curve for either carbon dioxide or methane emissions. Emissions for both gasses grow as income increases. It is also interesting to notice the vast differences between the average values of medium and high income countries; however, this gap is probably due to the way that the countries were split up into income levels and could probably be reduced if the countries were distributed differently. The regression analysis to follow will address this issue.

Another point to discuss is the percentage values for industry as a percentage of GDP. In the theory behind the environmental Kuznets curve, it's believed that low income countries will have low industry levels, medium income level countries will have the highest levels because they are in their industrial stages, and high income countries will have industrial levels that are lower than medium level countries. This discrepancy could be attributed to their transition into a service

economies. Yet when looking at the average percent values for industry in table 2, percentage of industry is rising at every level of income.

With all that said, it is important to remember that the descriptive statistics do not tell the whole story about these variables, it is simply a small piece of the puzzle. The purpose of this data is to set the foundation for the regression results and to get a better understanding of the data for each level of income. Despite the fact that the signs of an environmental Kuznets curve are not evident in Table 2, the existence of an EKC cannot be entirely ruled out. Therefore, we must turn to the results of the regression to investigate this data further.

### VI.B. Regression Results

#### VI.B.1. Carbon Dioxide

Table 3 shows the results for the carbon dioxide regression that was first presented in section 5. Three different models were run, with each new model more control variables are added until the full quadratic function is included in model 3. From a quick glance, we can see that model 1 and model 2 show evidence for the existence of a carbon dioxide environmental Kuznets curve, which is consistent with the findings of Franklin (2012), Yin (2015), Apergis (2016), and Yaduma (2015). However, this finding is not consistent with model 3. The only structural difference between model 2 and model 3 are the energy percentage variables. These three variables themselves are significantly different from zero but their presence greatly destabilizes the coefficients and significance of the other variables. EPC, EPNG, and EPO, show no sign of collinearity with the other variable. The only cause of this could be the large amount of omitted observations in these three variables. Model 3 has 59 fewer observations than both model 1 and model 2, which means that many meaningful observations included in the first two models are omitted in the third model. Therefore, during further analysis, the results from model 3 will not hold much weight.

The evidence of a carbon dioxide environmental Kuznets curve is a major find for a study of this magnitude. From the regression, we find that there is a positive sign for GDP and a negative sign for $GDP^2$. This tells us that there will be a point of inflection at some level of GDP. From the coefficients, this inflection point was calculated, and it was found that carbon dioxide emissions will continue to increase until a level of GDP between 84.3 and 84.4 million dollars per capita is reached and then they will decrease. This value seems economically impossible to obtain. The country with the highest GDP per capita is Luxembourg at 100,000 dollars per capita, so even though they have the highest per capita income in this study they have no chance of reaching this tipping point. Similarly implausible results were found in Bernard (2015). So, from these results we can see that there is an environmental Kuznets curve, but countries will never naturally grow to the tipping point estimated in this current study.

Now that we know that there is an EKC, how do education and government structure shift the EKC curve? From Table 3, mean years of education (MYOE) is not significantly different from zero in any of the models. Therefore, the hypothesis that high education levels should shift the EKC down could not be proven. According to the theory, higher education levels should be contributing towards citizens that are more aware of their environmental externalities and thus should be working towards reducing them (Dinda, 2004, Franklin, 2012, Yin, 2015, Marsiglio, 2016). There is also an understanding that as education increases cleaner and more efficient technologies should be developed and implemented, thus reducing emission outputs (Dinda, 2004, Yin, 2015). However, the result of these regressions, show no evidence for these theories. The

purpose for the education variables lack of significance is uncertain and creates avenues for further research.

**Table 3: Regression Results: Carbon Dioxide**

| Variables | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| GDP | .322*** | .326*** | .188* |
| | (5.024) | (5.093) | (1.722) |
| $GDP^2$ | -1.91E-6*** | -1.91E-6*** | 1.17E-6 |
| | (-2.395) | (-2.398) | (.647) |
| MYOE | .236 | .235 | .181 |
| | (1.509) | (1.499) | (.810) |
| CM | -5.675*** | -5.531*** | -5.111** |
| | (-3.958) | (-3.866) | (-2.987) |
| PAR | -5.807*** | -5.682*** | -4.177*** |
| | (-4.333) | (-4.251) | (-2.663) |
| PR | -6.016*** | -5.980*** | -4.936*** |
| | (-4.790) | (-4.780) | (-3.407) |
| CS | -2.616 | -2.349 | -1.331 |
| | (-1.184) | (-1.065) | (-.516) |
| OT | .745 | .118 | -2.785 |
| | (.307) | (.048) | (-1.055) |
| IND | | .042* | .021 |
| | | (1.791) | (.699) |
| AGR | | .016 | .056 |
| | | (.534) | (1.235) |
| EPC | | | .042* |
| | | | (1.944) |
| EPNG | | | .088*** |
| | | | (4.977) |
| EPO | | | .036* |
| | | | (1.721) |
| N | 174 | 174 | 115 |
| $R^2$ | .477 | .481 | .558 |
| *** Significant at the .01 Level | | | |
| ** Significant at the .05 Level | | | |
| * Significant at the .1 Level | | | |
| (t-statistic in parenthesis) | | | |

The most notable results from the carbon dioxide regressions are the values and signs for the dummy variables representing the government structures. Absolute monarchies can be considered highly totalitarian, hence countries that were structured under such a style were omitted

**Table 4: Regression Results: Methane**

| **Variables** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| GDP | 5.257E-5* | 6.14E-5** | .000*** |
| | (1.656) | (1.978) | (-2.651) |
| $GDP^2$ | -9.602E-11 | -1.701E-10 | 3.132E-9*** |
| | (-.243) | (-.440) | (4.879) |
| MYOE | -5.986E-5 | -4.026E-5 | 3.998E-5 |
| | (-.772) | (-.530) | (.005) |
| CM | -.002*** | -.002*** | -.003*** |
| | (-3.292) | (-3.289) | (-4.130) |
| PAR | -.002*** | -.002*** | -.002*** |
| | (-3.543) | (-3.289) | (-2.944) |
| PR | -.002*** | -.002*** | -.002*** |
| | (-3.223) | (-3.253) | (-3.209) |
| CS | -.001 | -.001 | -.001 |
| | (-.742) | (-.678) | (-.784) |
| OT | .000 | -.001 | -.001 |
| | (-.393) | (-.557) | (-1.575) |
| IND | | 1.991E-5* | 1.988E-5* |
| | | (1.737) | (1.850) |
| AGR | | 4.259E-5*** | 2.165E-5 |
| | | (2.982) | (1.339) |
| EPC | | | 5.338E-6 |
| | | | (.691) |
| EPNG | | | 2.709E-5*** |
| | | | (4.298) |
| EPO | | | 5.842E-6 |
| | | | (.773) |
| N | 174 | 174 | 115 |
| $R^2$ | .111 | .156 | .489 |
| *** Significant at the .01 Level | | | |
| ** Significant at the .05 Level | | | |
| * Significant at the .1 Level | | | |
| (t-statistic in parenthesis) | | | |

from the regression and used as a reference group for the rest of the dummy variables. In Table 3 coefficients of variables for constitutional monarchies (CM), parliaments (PAR), and presidential republics (PR) are all significantly different from absolute monarchies while communist states (CS) and other (OT) are not. Constitutional monarchies, presidential republics, and parliamentary style governments; all share aspects of democracy. While absolute monarchies, communist states, and government structures under that other category are more totalitarian and thus lack democratic rights. The most significant finding amongst these variables is the sign that they display. The variables for constitutional monarchy, parliament, and presidential republic all contain negative signs, meaning that every country that has one of these systems produces less emissions than countries with an absolute monarchy. The outcome from these results shows that more democratic governments are better equipped or more willing to address environmental issues or more specifically carbon dioxide emissions.

### VI.B.2. Methane

Though methane is the second highest greenhouse gas emitted, there have been no known studies that have looked at the possibility of a methane EKC. Therefore, there was no prior expectation for the results. What can be found from Table 4 is that there is no evidence for a methane environmental Kuznets curve, but, interestingly enough, many of the signs and significance values for a number of variables seem to be consistent with the results of the carbon dioxide regressions; thus, reinforcing some of the conclusions that were made about the previous results.

For example, model 3, which includes all of the variables that were first proposed, is just as unstable as model 3 in the carbon dioxide regression. By this, it is meant that the coefficients vary greatly from those presented in models 1 and 2. Again this is due to the large number of omitted observations because of mission data from the three energy variables (EPC, EPNG, EPO). Another point of similarity is the three government variables, constitutional monarchy (CM), parliamentary (PAR), and presidential republic (PR). In all three of the models, the variables are highly significant and have negative signs. So even though there is no inverted U-shaped methane Kuznets curve these, variables still shift the curve down. This evidence only reinforces the conclusion that more democratic structures are more likely or more willing to set forth agendas that lessen the emissions of harmful greenhouse gasses. Once more, education levels do not have a discernable impact on emissions. This goes against the proposed hypothesis and the theory presented, showing an opportunity for further research. As expected, the variable for agriculture as a percentage of GDP shows to be highly significant, which highlights that agricultural practices have a small yet noticeable impact on overall methane emissions.

## VII. Conclusion

This study sets out to look for evidence regarding the existence of an environmental Kuznets curve for the greenhouse gasses of carbon dioxide and methane. This paper also looks to understand the relationship that emissions hold with education and government structure. It was believed that education levels would shift the curve downwards while the government structure variables would have an undetermined effect. This type of study fits in with previous literature that looks at additional control variables that might affect the shape and movement of the EKC (Franklin and Ruth 2012, Yin et al 2015, Marsiglio et al 2016). Additionally, this study adds to past research by including empirical models for methane per capita and investigating the relationships between emissions per capita, education levels, and government regimes.

In order to test the hypothesis, six quadratic models were employed. Descriptive statistics were presented in order to create a preliminary story of the data used for this study. From the simple observation of the descriptive statistics, there does not seem to be evidence for an EKC for either of the greenhouse gasses. However, trends in industry as a percentage of GDP and agriculture as a percentage of GDP provide evidence to the economic development theory behind the environmental Kuznets curves.

The results of the regressions for the two emission types were then put forth and discussed. It was found that there was a carbon dioxide Kuznets curve with a tipping point between 84.3 and 84.4 million dollars per capita, but not a methane emissions EKC. It was also found that substantial evidence could not be provided to prove the validity of the hypothesis regarding the levels of education. However, this study was not fruitless because in both the carbon dioxide and methane regressions, three of the government variables, including constitutional monarchy (CM), parliament (PAR), and presidential republic (PR), prove to be significantly different from an absolute monarchy and even show to shift the curves down wards. These results present evidence that the more democratic government styles are more able or willing to enact legislation to reduce the output of carbon dioxide and methane emissions.

From the results of this work, it is not possible to derive direct policies; however, it does bring up data that should be considered when understanding the effects that a country's political ideology has on environmental policy. Also, the result show that we cannot grow to a point of decreasing emission, actions must be put in place if we wish to see this happen. Ultimately, the results from this study bring forth more questions and areas of future research than it is able to answer. The low number of observations due to the many database omissions could lead to omitted variable and selection biases that could have colored the results of this study, therefore further research should be done to fill the holes that this study could not. Also, further studies should look deeper into the connections between education and emissions. Found theory suggests that high levels of education should reduce emission levels but in this study no evidence could be brought to support these notions. Research on the environmental Kuznets curve hypothesis should also continue, this hypothesis holds promise for political policy but evidence for this hypothesis has greatly varied between studies. Though the results of this study could not support all of the hypotheses presented in this paper, it provides a sturdy foundation for future work researching the environmental Kuznets curve and it helps to move this area of research a step closer to a consensus on the much-debated environmental curve.

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