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META-ANALYSIS OF ENVIRONMENTAL KUZNETS CURVE STUDIES: DETERMINING THE CAUSE OF THE CURVE'S PRESENCE

Brittany Goldman

I. INTRODUCTION

Worldwide public concern of the quality of our environment has ignited large efforts toward finding the determinants of environmental degradation. The Environmental Kuznet's Curve (EKC) hypothesis models the relationship between levels of environmental degradation and income in a given economy and has been a topic of high debate in recent years. This concept hypothesizes the relationship between per capita income and the level of environmental degradation in an economy is an inverted U-shape. This focuses upon the idea that economic growth is necessary for environmental quality to be maintained or improved. Following Grossman and Krueger (1992), who first described the EKC, a deeper understanding of the empirical relationship between income and environmental quality has been rapidly evolving through recent studies of the EKC hypothesis.

The EKC is commonly found both present and absent in many different empirical studies, thus spurring controversy of the topic. An abundance of empirical literature exists; however, the level of doubt arises considering the majority of EKC studies rely solely on empirical evidence. EKC literature contains many studies that employ different methods, evaluate different environmental indicators, and use different data, resulting in a broad spectrum of findings which lead to conflicting interpretations. However, there are a limited number of attempts of systematically surveying the EKC literature using meta-analysis to discover what has been learned through past research concerning the existence of the curve.

Since 1991, the EKC has become a standard feature in environmental policy, though its application is highly questioned as an effective tool for policy implementation (Roberts and Thanos, 2003). If there existed evidence of specific factors that lead to a true EKC form in a given economy, then policy makers could heavily depend upon the EKC as a core policy tool for controlling environmental quality. Uncertainty lies in the question of whether results from previous research are reliable enough to be used for policy formation. Intuitively, if economies with higher income levels naturally pollute the environment less, then policies that stimulate growth should be good for the environment.

Cavlovic et al. (2000) conducted the first meta-analysis of the EKC hypothesis, using a compilation of EKC studies from the early 1990s. She researched 25 studies using 155 observations and considered 11 different environmental degradation measures. Cavlovic's study found that methodological choices can significantly influence results. A second meta-analysis was conducted shortly after by Li et al. (2007). Using the data of the 25 studies from Cavlovic et al. (2000), additional observations were added to update her database to 77 studies which provided 588 observations in total. This study looked at two broad categories of greenhouse gases: anthropogenic activity-related and chemically-active gases. Li et al. (2007) ultimately found no statistically significant evidence that supports the EKC for anthropogenic activity-related gases.

The importance of this topic is derived from the question: what variations and factors of all empirical studies affect the absence or presence of the EKC curve? The objective of this study is to answer this question by further expanding upon past meta-analyses conducted on empirical EKC studies. As many empirical EKC studies continue to be completed, it is important to systematically examine this body of literature so we can come to a better understanding of the key determinants of environmental degradation and its relationship with income supported by the EKC hypothesis.

For this study, I hypothesize that the type of pollution and level of a country's development will be a key determinant of the presence of the EKC in a specific study. All things considered, the type of pollution is commonly the main focus of empirical research of the EKC, thus showing that this factor is likely to be of significance when looking for an EKC relationship. Studies frequently look at a few types of pollution within a given paper and analyze the data for each of the pollutions separately. In addition, since countries show significant differences in political, social, and economic biophysics factors, it can be expected that different countries exhibit different patterns for their relationships between environmental quality and income (Figueroa & Pasten, 2009). Other factors may be significant to the curve, but based on economic theory, I hypothesize that the type of pollution and level of economic development in a country will have the largest effects.

II. LITERATURE REVIEW

The Environmental Kuznets Curve is a concept that first emerged in the early 1990s hypothesizing the relationship between per capita income and level of environmental degradation has an inverted U-shape. As mentioned earlier, this concept focuses upon the idea that economic growth is necessary in order for environmental quality to be maintained or improved (Stern, 2004).

The EKC hypothesis was made popular by the World Bank's World Development Report 1992, which argued that greater economic activity inevitably hurts the environment based on status assumptions of technology, tastes, and environmental investments (WRI, 1991). As income increases, the demand for improvements in environmental quality increases, as well as resources for available investment to improve the environment. Others have claimed that economic growth leads to environmental degradation in the earlier stages of growth, meaning the only way to attain a healthy environment is to become rich. Researchers believed at higher levels of development, structural change within the economy towards information-intensive industries, services, increased awareness of the environment, enforcement of regulations, and improved technology result in the decline of degradation. Therefore, theory suggests a number of causes of the EKC, including environmentally friendly economies of scale in production, changes in product mix, changes in technology, changes in input mix, and underlying social considerations such as regulations, awareness, and education.

Scale implies that expanding production increases emissions or given scale economies/diseconomies of pollution, there could be proportional increase in pollution. In earlier phases of development, output mix changes, and there is a shift away from agriculture that moves towards heavy industrial production leading to increased emission. However, in later stages, the economy shifts to less resource intensive work of services and lighter manufacturing, thus decreasing emissions and explaining the fall of environmental degradation. Input mix is the idea that substitution of less environmentally damaging inputs is replaced for more environmentally damaging inputs and vice versa. Changes in technology increase levels of productivity. Being more productive will result in less pollutants being emitted per unit of output. Emissions process changes can result in less pollutants being emitted due to innovations directly related to lowering emissions. Policies developed after pollution becomes an issue can lead to the fall in environmental degradation. Also, educating the population on harming the environment as it becomes a prominent issue, could lead to the eventual decline in pollution. Thus, all of these concepts support the inverse-u shape of the curve as an economy develops.

Many empirical EKC studies are concerned with answering the question: is there an inverted U-shape relationship between environmental degradation and income? (Galeotti et. al, 2008). Past literature narrows the focus of EKC studies by looking specifically at different variables. Many empirical studies in recent years have tested the EKC hypothesis through different environmental indicators, countries, regions, and econometric techniques (Ekins, 1997). EKC studies of different focuses have grown to become controversial since the first outbreak of EKC research in the 1990s. Given the broadness and large potential for research of the EKC, many concluding results from numerous EKC studies are very conflicting with one another. Findings from such an abundantly researched topic have developed in recent years to determine if economies actually pollute their way to growth, or, conversely, if economies reduce pollution as they grow. These studies focus on what specific features support the EKC hypothesis.

Several studies focusing on the same pollution type have revealed contradicting results of the presence of the EKC relationship between pollution and income. For example, Aslandis and Iranzo (2009) studied CO2 emissions of multiple countries from 1971 to 1997. No evidence was found of an EKC present from CO2 emissions using econometric techniques for transition regressions with panel data. On the contrary, in a study utilizing a semi-parametric panel model for CO2 emissions in 15 Latin American countries (Poudel, 2009), results show an N-shaped curve, which is sensitive to the removal of some groups of countries. An N-shaped curve is the same as the standard EKC shape except after environmental degradation falls, pollution begins to increase again and the curve moves back up. An example of the N-shaped curve is shown in Figure 1. Not only

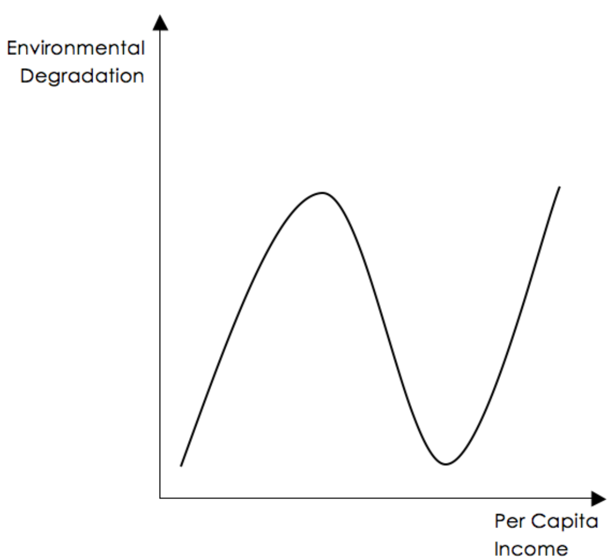

Fig. 1. N-Shaped Environmental Kuznets Curve

are both studies producing contradicting results, but the latter found sensitivity among certain countries included in the study. Considering that the level of development is what usually differentiates these countries from one another, it is evident that the level of development of countries within a study will affect the presence or absence of an EKC in addition to the pollution type.

A largely reoccurring criticism of EKC studies is the omission of relevant explanatory variables (Galeotti et. al, 2009). Many studies are conducted using panel data sets of individual regions and countries throughout the entire world. Some studies group together certain countries while others test each country individually. Different results from these methods plays into the regional effects that have been found among certain results, which bring up the question of whether or not the countries studied ultimately affects the presence of the EKC.

Many studies have shown that the country being studied truly affects the results of the relationship between income and environmental degradation. In Lee et al (2010), water pollution was looked at upon 97 different countries within the years 1980-2001. Empirical results showed evidence of an inverted U-shape relationship in American and Europe countries, but no relationship shown in Asian and Oceania countries, thus strongly supporting the regional effect of EKC studies (Lee et al, 2010). Reasoning for this effect was due to the majority of the Asia Oceania group being low income countries, thus affecting the presence of the EKC hypothesis.

In Fodha and Zaghdoud (2010), both CO2 and SO2 were considered for a small and open developing country. Although tests were performed on the same country within the same time frame, results of the two different pollutants were not the same. An inverted U-shape relationship between SO2 emissions and GDP had been found whereas a monotonically increasing relationship with GDP was found for CO2 emissions. EKC presence among SO2 emissions can be explained by the fact that SO2 mainly affects the regional population as opposed to the global population. Also, in the specific country of this study, there are limited numbers of emission sources and investment can easily reduce emission levels (Fodha and Zaghdoud, 2010). This study provides another example of how country variance can truly affect the presence or absence of an EKC relationship. In addition to Fodha and Zaghdoud, another study of sulfur emissions in different countries found evidence of the EKC hypothesis (Leitão, 2010).

As different econometric techniques have been utilized in past research, a large number of results from specific techniques tend to differ based upon methods used. In a study based on environmental degradation and its relationship to income in China, all three pollutants of waste gas, waste water, and solid wastes have shown results of an inverse U-shape in support of the EKC hypothesis using a panel cointegration method (Song et. al, 2007). Panel data is very commonly used among most EKC studies. A similar study done using integration and cointegration tests predominantly produced results supporting the EKC hypothesis as well (Galeotti et. al, 2009). Whereas, a different study was performed using smooth transition regressions with panel data and found no evidence of the EKC hypothesis (Aslanidis and Iranzo, 2009). Methodology used within these studies ultimately affects the resulting relationship between income and environmental degradation.

Clearly the focus of the majority of published EKC literature revolves around specific variables chosen for the study. The differences among economies and how to approach looking for the relationship between environmental degradation and income produce diversified results. Despite all of the past EKC literature, there is still much left to be found regarding systemic patterns within a study to determine whether an EKC would be observed or not. In order to look through the large magnitude of EKC studies, Li et al. (2007) used a meta-analysis to investigate empirical EKC studies from 1992 to 2005. Li's meta-analysis, investigating EKC studies from nearly 13 years total, was the first attempt to fill that gap of reasoning behind the presence or absence of an EKC. I will further the exploration of determining the factors influencing the presence and absence of an EKC through my own meta-analysis by investigating EKC studies from the years 2006 through 2011. My study is done with the intent to find significant factors that affect the curve by using more recent findings as opposed to past studies that are already completed and analyzed.

III. META-REGRESSION ANALYSIS AND DATA

A meta-analysis is a statistical approach used to integrate the findings of a large collection of results among different empirical studies, all with a common factor of a specific topic. The purpose of a meta-analysis is to reach meaningful conclusions relative to past literature on a specific topic and further explain the reasoning for specific results. A meta-analysis is commonly structured in regression form. Observations from every study are individually collected and transcribed based upon the results of the studies. Every explanatory variable is a characteristic of an individual observation (i.e. method type, GDP, developed country, etc.) which is then aggregated into a single database. The process of performing a meta-analysis is both time consuming and complex. The following sections take a deeper look into the process of collecting data for a meta-analysis: determine variables, identify the literature to be analyzed, identify individual observations in each

Table 1: Model Variables

	Variable	Descriptions
Dependent Variables	RELATION	Indicator variable of the environment-income relationship. If an inverted U-shape or a monotonically declining trend is found then =1; if an insignificant inverted U-shape exists then =2; any other results fall under the category "else" =3.
Data-Related	LNOBS	Logarithm of the number of observations.
	LNTIME	Logarithm of the data coverage period.
	PANEL	Indicator variable of the data in the study; if panel data is used then PANEL=1, else=0.
	GLOBE	Indicator variable of using multi-country data; if yes GLOBE=1; else=0.
Variable Controls	EMISSION	Indicator variable of using emission as the pollution measurement, true=1, else=0.
	GDP	Indicator variable of using GDP as the income measurement in a study, true=1, else=0
	DEVLPED	Indicator variable of whether data comes from developed countries or not. If yes, DEVLPED=1; else=0.
Statistical Methods	FITNESS	Fitness of the regression in a study (percentage).
	TEST	Indicator variable of applying robustness test for regression results; if applied, TEST=1, else=0.
Environmental Quality Degradation Categories	ANTHPGR	Indicator variable of anthropogenic activity-related greenhouse gases; if yes, ANTHPGR=1, else=0.
	CHACTGR	Indicator variable of chemically-active greenhouse gases; if yes, CHACTGR=1, else=0.
	BIOREL	Indicator variable of biologically-related pollutants; if yes BIOREL=1, else=0.

Table 2: Sample of Dataset

AUTHOR	RELATION	LNOBS	LNTIME	PANEL	GLOBE	EMISSION	GDP	DEVLPED
Song	1	1.099	2.996	1	0	1	1	1
Song	1	1.099	2.996	1	0	0	1	1
Song	1	1.099	2.996	1	0	0	1	1
Biagliani	3	1.792	0	1	1	1	1	0
Biagliani	3	1.792	0	1	1	1	1	0
Biagliani	3	1.792	0	1	1	1	1	0

study, transcribe the data, and conduct a statistical approach.

A. Step 1: Determine Variables

The first step to conducting a meta-analysis is to decide what specific variables will be collected and used from past studies in order to formulate a complete database. The list of variables must be relative to the theory within the meta-analysis and also be present in the studies being analyzed. Because my study furthers the exploration of determining the factors influencing the presence or absence of an EKC, I chose to replicate the variables used in Li et. al, 2007 (see Table 1). My study is completed with the intent to find significant factors that affect the EKC by using more recent findings. To maintain a fair level of comparison from this meta-analysis to Li's, I remain consistent by using the same variables as in Li's meta-analysis.

B. Step 2: Identify the Literature to be Analyzed

The next step is to identify what literature will be used in relation to the topic of the meta-analysis. Because I am looking at more recent findings about the EKC, I created a set of criteria to filter through the abundance of literature published on EKCs. I decided to only use peer reviewed empirical studies that were published after the year 2005. Only empirical studies could be used because theoretical studies do not produce the variables needed for my meta-analysis. For example, an obvious variable needed is the resulting shape of the curve found from using an empirical model in a given study. Theoretically supported studies would not provide any empirical evidence or resulting pattern of data that is needed for my analysis. Also studies used must be after the year 2005 in order to prevent overlapping data with Li's past meta-analysis. I am using a total of 20 studies published between the years 2006 and 2011.

C. Step 3: Identify Individual Observations in Each Study

Now that the list of variables to look for and the collection of literature is complete, it is time to identify individual observations in each of the studies. The unit of observation is "a study." Each of the studies produces values for the variables defined in step 1. One single study is not limited to any number of observations. That is, one study can easily produce 15 different observations. For an example of what multiple observations look like, refer to Table 2.

Table 2 shows part of the dataset after completion. Notice the author Song fills up three rows of data. The three rows of values corresponding to the author, Song, show three different observations pulled from Song's published study. In Song et. al, 2007, three different types of pollution were tested: waste gas, waste water and solid wastes. These different pollutions qualify for separate observations within one study because they affect the value of the EMISSION variable. Only one pollutant can be considered at a time, so the study must be broken down by pollution types.

D. Step 4: Transcribing the Data

After identifying each individual observation, the data collected from every study must be assigned a value and coded into the dataset. As shown in Table 1, most of the variables are dummy variables aside from a few that hold actual values, i.e. LNTIME and LNOBS. The actual values are simply recorded with their corresponding study. Referring back to Song et. al, 2008 from Table 2, the first line shows a "1" under the EMISSION's column. Based off the description of the EMISSION variable in Table 1, a "1" for EMISSION represents a variable in which emissions is the pollutant being observed. This type of transcribing is done for every single variable being considered in the meta-analysis for every study used in the database. Using a data base of 20 studies from the year 2006 through 2011, 78 observations were collected in total for this study.

E. Step 5: Taking a Statistical Approach

The last step of the meta-analysis process is taking the formulated dataset and applying a statistical model to it. No meta-analyses are restricted to any one given model just as any other research topic is not limited to taking a specific statistical approach. For this study I will be using the STATA program to run a multinomial logit model as explained in the next section.

Overall, a meta-study allows a much wider and diverse net to be cast than a traditional literature review. Because it uses econometric techniques, meta-analysis is excellent for highlighting correlations and links between studies that may not be readily evident as well as ensuring that the researcher does not subconsciously infer correlations that may not exist. Rather than relying on descriptive literature or individual results of a single study, a meta-analysis has the capability of "analyzing the analysis," thus controlling for a large variety of factors and potentially resulting in an improved statistical interpretation of the results of multiple pieces of literature.

Limitations of meta-analyses arise from potential selection biases, publication biases, and skewed data. Also, certain studies may not have variable results that perfectly fit into all the categories. The researcher compiling the data must make sure that all research is quantitative, rather than qualitative, and that the data can be compared across various researches to allow for a genuine statistical analysis.

The most recent EKC meta-analysis (Li et al., 2007), contained 77 studies and 588 observations. These studies included published papers (83%), book chapters (4%), and working manuscripts (13%) (Li et al, 2007). For the purpose of my study, the data will only consist of peer reviewed papers. My study builds on Li's by including EKC studies that were conducted after the publication of Li's meta analysis.

The dependent variable used for my study is a trichotomous categorical response variable titled RELATION as represented in Table 1. First, the types of curves found in all observations can be categorized into seven different variables. These seven types of curves are then grouped into 3 main categories used for the dependent variable. The seven environmental-income relationship variables are: (1) monotonic increasing, (2) monotonic decreasing, (3) inverted U-shape (EKC), (4) U-shape, (5) N-Shaped, (6) insignificance (INSIG), and (7) none. Insignificance means that the estimated coefficients have consistent signs for an EKC relationship to be existent, but the results are not statistically significant in the observation used from empirical results of the individual studies in the database. None refers to when no relationship exists.

The seven types of curves are then categorized into three categories for the purpose of the multinomial analysis. Ultimately, the three categories representing the type of curve are used as the dependent variable. The first category is when environmental quality improves (IMPROVE), the second category is when results show evidence of an EKC curve but are insignificant (INSIG), and the third category (NONE), is every other relationship including no relationship at all. To define each of the three relationships, IMPROVE means that as an economy grows, the level of pollution improves meaning the environmental quality is increasing. Studies resulting in insignificant EKCs are a part of the INSIG category, and observations with no relationship or any other pattern not in the previous two categories fall in the ELSE category. These groups are summarized into the three RELATION groups representing the dependent variable in the multinomial logit model.

All of the following explanatory variables are derived from the studies examined and transcribed into the database used for this meta-analysis. The unit of observation is "a study." Each of the studies that have been examined has a value for the variable being defined. The explanatory variables are grouped into four different categories: data-related, variable controls, statistical methods, and pollutant categories. The data-related variables are dataset characteristics of the examined studies. Variable controls are the set of explanatory variables that are used in an EKC study as well as the statistical controls. The statistical method variable represents whether or not a specific econometric test was run.

The four variables in the data-related group are: (1) the time span of the data covered in the study (LNTIME), (2) data size of number of observations in log terms (LNOBS), (3) whether the study uses panel data or not, (4) the geographic aspect of the study whether or not the information is pulled from one or more countries (GLOBE). The variable controls subgroup includes 3 variables to capture the distinction between different studies: (1) Whether the pollution is measured through emission (EMISSION), (2) whether the study uses GDP as a measurement of income (GDP), (3) whether a study uses data from a developed country or an undeveloped country (DEVLPED). The statistical subgroup specifies what type of modeling is done in order to clear up any criticisms of model type within a study: (1) goodness-of fit measure as in R^2 or adjusted R^2 (FITNESS) and (2) evidence of robustness test for heteroscedasticity, fixed effects, cointegration, etc. (TEST).

Although there are many other potential categories for the environmental indicator variables, the studies will be isolating the (1) anthropogenic activity-related greenhouse gases (ANTHPGH), (2) chemically-active greenhouse gases (CHACTGR), and (3) biologically-related indicators (BIOREL). In addition, the same variables used in the meta-analysis by Li et al (2007) will be used in my meta-analysis. However, multiple variables have been omitted due to the smaller size of the database and the incomplete information resulting from specific studies not all producing the same variables.

Table 3: Results

Variables	Column 1	Column 2	Marginal Effects
	IMPROVE	INSIG	IMPROVE
LNOBS	-0.073	0.202	-0.041
	(0.123)	(0.241)	
LNTIME	0.081*	-0.053	0.028
	(0.043)	(0.056)	
PANEL	-17.418	-17.954	-0.341
	(2616.829)	(2616.831)	
GLOBE	1.47	0.425	0.128
	-1.104	(1.526)	
EMISSION	-20.812	-20.887	-0.086
	(4358.394)	(4358.394)	
GDP	-16.626	-18.841	-0.451
	(2519.238)	(2519.238)	
DEVLPED	2.647**	-2.381	0.290
	(1.259)	(3.274)	
CONSTANT	51.533	54.420	
	(5673.619)	(5673.619)	
Number of Observations	78	78	78

Notes:
1. Standard errors are included in parenthesis
2. * denotes significance at the .10 level
3. ** denotes significance at the .05 level

IV. EMPIRICAL MODEL

The response variable (or dependent variable) used is trichotomous, meaning there are three potential categorical responses. Because this model has a qualitative dependent variable, the objective is to find the probability of observing an inverted U-shaped EKC, an insignificant EKC relationship, or no relationship at all. Thus, qualitative response regression models, known as probability models, are employed.

The categorical dependent variable for the environment-income relationships is RELATION. As described before, the RELATION variable is grouped into three categories: category 1 (IMPROVE); category 2 (INSIG); and category 3 (ELSE) as defined in the previous sections. IMPROVE means that there is an EKC present in the study. INSIG means an EKC was recognized, but was also statistically insignificant. ELSE represents the category containing any other shaped patterns (i.e. U-shaped, N-shaped, etc.) and no relationship/EKC found. A weighted multinomial logit model (MNL) of the probability of RELATION is given by:

$$P(Y_i = j \mid C) = \frac{\exp(\beta_j' x_i)\,,}{\sum_{k \in C} \exp(\beta_k' x_i)}$$

Where as $P(Y_i = j \mid C)$ is the probability that the relationship category falls in alternative *j* within set C, and C = {IMPROVE, INSIG, and ELSE} for study *i*. β_j and β_k are vectors of the explanatory variables' coefficients, and x is a vector of study-specific modeling choices. In order to find the effects of each specific attribute of choice *k* on the probability P_j, we calculate the elasticities of the probabilities (Greene, 2003). The third category, ELSE, is set as the base category. Thus the explanatory coefficients of one category produced explain the probability of the variables in that category showing an effect against the base RELATION, ELSE. That is, for one given explanatory variable coefficient from IMPROVE, the value of the coefficient explains the probability of that variable producing an IMPROVE relationship over and ELSE relationship.

V. EMPIRICAL RESULTS

The estimated results of the multinomial logit model (MNL) for investigating different EKCs relationships are presented in Table 3. When running the logit model, multicollinearity was the main issue when attempting to incorporate all variables as shown in Table 1. Note that not all variables listed in Table 1 are included in Table 3 due to missing data from specific observations, as well as the main issue of multicollinearity among the data.

Multiple problem variables were removed and the remaining variables, as shown in Table 3, represent the ultimate variables used for the final model. The variables not included in Table 3 are GDP, FITNESS, TEST, ANTHPGR, BIOREL, and CHACTGR. The multinomial logit was originally run with all variables listed in Table 1, but many of the variables were removed. All of the data-related variables produced significant outputs when included in the different combinations of variables tested. Ultimately the remaining variables used within the model were LNOBS, LNTIME, PANEL, GLOBE, EMISSION, GDP, and DEVLPED. Refer to Table 1 for descriptions of the variables.

The coefficients of the MNL are somewhat difficult to directly interpret. Table 3 shows three columns, IMPROVE, INSIG, and marginal effects of IMPROVE only. The three categories of the dependent variable are IMPROVE, INSIG, and ELSE. Within the database, a 1 represents IMPROVE, a 2 represents INSIG, and a 3 represents ELSE. The third category, ELSE, is used as the reference category within the model in order to compare instances when an EKC was present against when there was no EKC pattern present. Since the dependent variable is trichotomous, the effects of the explanatory variables are shown through the calculations of the elasticities of probability. Elasticities are calculated for continuous variables to represent a small increase in original mean values. The elasticities produced in Table 3 indicate how a one unit change in the independent variable (or equaling one in the case of a dummy variable) affects the probability of the occurrence of the "category." For example, LNTIME is compared to the number of years increased by one. For the dummy variables, elasticities are calculated from 0-1.

Given the limited number of observations used within the database for the purpose of this study, it is not surprising to find only two out of the nine variables included in the final model to be significant among the IMPROVE category and no statistically significant variables in the INSIG category. The only data-related variable found to be significant at the 0.10 level was LNTIME (which is the natural log of the number of years data was collected in a given study). This can be interpreted as meaning when the number of years in a study increases by one, the probability of finding an IMPROVE relationship increases by 0.028, ceteris paribus.

DEVLPED is the only variable control that significantly affects the probability of finding an IMPROVE relationship. DEVLPED is a dummy variable that represents if a country is either developed or undeveloped/developing. Relative to the base category (WORSEN), the variable of whether a country is developed affects the probability of finding an EKC. Using a developed over an undeveloped/developing country increases the probability of finding an EKC curve by 0.290. None of the variables had significant probabilities of finding an INSIG relationship over the ELSE relationship.

Both LNTIME and DEVLPED coefficients held positive elasticities values as predicted. Aside from LNOBS, LNTIME, and DEVLPED, all other variables had the same signs and nearly the same coefficients when comparing the IMPROVE coefficients to the INSIG coefficients. The estimation results of the dummy variables for IMPROVE and INSIG are majorly consistent. Not only were the coefficients close in value, but the signs were the same as well. Regardless, all of the remaining variables that were consistent between the two categories were not statistically significant.

VI. CONCLUSION

Taking a look at the meta-analysis results, it is fair to say that literature results showing inverse–U shape curves statistically insignificant are no different than seeing no significant findings for the categorical relation INSIG. This makes sense logically because when comparing category INSIG to the reference category ELSE, the insignificant coefficients of INSIG's variables explain the probability of a specific explanatory variable leading to an insignificant U-shape curve instead of no relationship. These two things are the same because either way, the resulting relationship is not going to be the EKC, which is the ultimate goal of this project. Intuitively, it makes sense that there would be no significance in any of the explanatory variables when looking among category INSIG, considering that category would explain what determines the output of an insignificant U-shaped curve.

The evidence presented in this paper shows that there are two significant explanatory variables that lead to the presence of the EKC, time and developed countries. These two explanatory variables make sense intuitively to be significant. The time factor holds importance by basically suggesting we need to allow for a passage of time in order to observe a "turning point" of a country's level of pollution. The major idea that can be concluded from these two factors is the concept that countries pollute their way to growth. Considering that there is a positive and significant coefficient for the time and developed variables within category IMPROVE, this shows that there is a significant probability existent showing the odds of a study to result in the EKC curve increases if the country being viewed is developed and looked at over a long period of time. Development that occurs over a period of time eventually causes EKCs to invert. Thus, economies eventually grow themselves toward a cleaner environment. In respect to my hypothesis, predicting the development of a country to significantly reflect the presence of the EKC curve was fairly accurate given that DEVLPED was one out of the two only significant variables resulting in this study.

This idea of developed countries exhibiting this pattern over time is relevant in deciding if people should invest in countries from abroad to stop pollution from occurring. Polluting the way to growth provides negative externalities upon the increase in pollution levels. Policies should be implemented that provide incentive for countries to become environmentally conscious without majorly polluting their way to a certain point of wealth that make caring for the environment affordable. In addition, policies that stimulate growth are an option to be implemented if ultimately an economy is going to grow enough to sustain a cleaner environment.

In addition to the DEVELPED variable, the idea that length of a study increases the probability of finding an EKC present can lead to the idea that investment and policy should not be spent on economies that are near being completely developed. Also, knowing that it takes time to see the EKC pattern in a given economy, policy makers are going to be able to better predict a time frame to see policies actually take an effect on the environmental quality. Ultimately, findings from this study show that policies to better the environment will take a long period of time and do not provide and instant betterment of an economy's environment.

Given the limited amount of data used within this set of studies from the year 2006 through 2011, further research can expand upon this study by adding both past and even more recent published studies of the EKC. A larger and more variable dataset will provide the variation needed to avoid issues of multicollinearity and also make the results stronger knowing they would incorporate findings from the majority of works published about the EKC and what defines its existence.

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