Environmental Kuznets Curve Hypothesis? or Pollution Haven Hypothesis? A Comparison of the Two

With the world becoming a global economy and global trade necessary, the concern for environmental quality has increased. There are an increasing amount of empirical studies devoted to the Environmental Kuznets Curve (EKC) theory, to determine the relationship between a country's income and its pollution levels. The EKC theory basically states that initially as a country's income increases its pollution increases, but at a certain level of income its pollution levels will start to decrease.

The existence of the EKC hypothesis that has been shown through empirical studies raises one main question. Should the evidence supporting the existence of the EKC be used to set policy measures? Or, does it just show a relationship that should have no impact on policy decisions? One explanation for the existence of the EKC is the pollution haven hypothesis. It basically states that when countries start to import more goods the industries they used to produce these goods have moved to other countries taking the pollution created by them to those countries.

I will first determine if the EKC hypothesis holds true for CO2 emissions related to income in a cross sectional data set for 156 countries. Second, I will narrow the field to two countries, the U. S. and Mexico, to see if evidence can be found to support the EKC hypothesis. I will use CO2 emissions related to GNP that is matched for each of the countries. Comparing each of the data sets for each of these two countries may offer insight to the pollution haven hypothesis as well. Finally, I will do a comparison of economic indicators to CO2 emissions for Mexico to determine if the EKC and pollution haven hypothesis are related. Reviewing literature on pollution, the EKC and the transfer

of pollution through trade are important to understanding the relationship between a country's growth and its environment.

CO2

CO2 is one of the most common air pollutants in the world. This gas is released naturally into the air by decaying plants and animals but is dramatically increased by the burning of petroleum products. Deforestation from clear-cutting and burning also greatly increase the amount of CO2 released into the atmosphere. Both of these, use of petroleum products and deforestation, typically characterize an industrial country whose national income is increasing. The question is; will these country's CO2 emissions continue to increase as their national income's increase? Schmalensee, Stoker and Judson (1998) state in their paper, ***World Carbon Dioxide Emissions: 1950 – 2050***, that: "Most scientists consider it likely that if the atmospheric concentrations of carbon dioxide and other so called green house gasses continue to rise, the earth's climate will become warmer." (15) With industrialization growing stronger in many of the developing countries, the need for fossil fuels and the clearing of land has greatly increased. They also state that: "Emissions of CO2 caused by human activity are generally considered the most important single source of potential future warming." (15)(1998) Currently many of these counties are not concerned about what the effect will be in the future, while increasing carbon dioxide emissions today.

With carbon dioxide emissions increasing global warming, it is hard to say what the effects will be in the future. I agree with Schmalensee, Stoker and Judson (1998) when they state: "little is known about the likely costs and benefits of such warming, it seems clear that both depend critically on the rate at which warming occurs." (15) One of

these effects could be the change in the climate of countries. A country that all ready has a warm moist climate, whose main source of production is agriculture, could turn into a hot dry climate. This might drastically affect what that country could produce. If a country has a cold dry climate and is mostly an industrial producing country, a change in climate to a warmer moister one could allow that country to create new areas of production, such as agriculture. A warming climate could affect more than we actually see the effect on the oceans could be significantly great.

Previous Studies

Carlo Perroni and Randall M. Wigle (1994), in their paper "International Trade and Environmental Quality: How important are the linkages", try to find a relationship between trade and the environment. Perroni and Wigle state: "This paper represents an attempt to assess the relative contribution of international trade to environmental degradation, and the extent to which environmental policies affect the size and distribution of the gains from trade liberalization." (552) The amount of pollution allowed from industries varies for different countries; some of the questions Perroni and Wigle are trying to answer are if countries move industries to take advantage of weaker environmental policies or other non-environmental factors, such as cheaper labor. To do this they explain four externalities that could effect the environment. The first is institutional processes, which accounts for a lack of a market for pollution to the environment. The second is technological processes which help to determine not only the cost of cleaner technology but different abatement processes the third is natural and geographical processes because how pollution effects the environment can depend on the location of the country. The final one is subjective process, which takes into account how

a countries wealth could determine what type of environment it desires (Perroni and Wigle, 1994). Each of these externalities would be important to account for when trying to determine how trade could effect the environment. Using these in their model showed no significant changes for an increase or decrease in environmental degradation due to trade policy. They do state however that "In spite of our efforts carefully to separate the various aspects of environmental externalities, our numerical findings must be viewed as exploratory, owing to our limited knowledge of precisely how environmental emissions impact on the environment." (565)

The externalities that Perroni and Wigle used in their paper are strongly related to the EKC hypothesis. Each could explain why a country's pollution levels decrease after a certain level of income is reached. Grossman and Krueger in their paper, "Economic Growth and the Environment", try to determine if increases in economic growth adversely affect the environment. They used panel date across several different countries to determine the relationship between pollution and income. From their findings they state that "we find no evidence that economic growth does unavoidable harm to the natural habitat. Instead we find that while increases in GDP may be associated with worsening environmental condition in very poor countries, air and water quality appear to benefit from economic growth once some critical level of income has been reached." (370). Even with their findings supporting the EKC, they offer some explanations as to why they may do so. Consequently, their reasons correlate with the externalities given by Perroni and Wigle (1994). They emphasize that countries could have been switching to cleaner technologies to help reduce pollution and that countries that have attained a certain level of wealth while wanting better environmental conditions began importing

pollution intense goods from countries with less stringent environmental policies (Grossman and Krueger, 1995).

When researching for this paper I read numerous papers that were wrote trying to find imperical evidence to explain the Environmental Kuznets Curve. Most of these papers agree that there is a relationship between pollution and income that show and inverted U – shape pattern. What most of these papers did is explain that there can be many different reasons why a country's pollution levels would decrease after a certain level of income is reached. Pollution could decrease because of its environmental laws. This would cause a country to try and import products that other wise would be more expensive to produce on a cleaner basis for them (Grossman and Krueger: 1995). I believe for this to happen the diversification of income across a country must be relatively even. If the majority of the income, say 80 to 90 percent, is possessed by a few people and the rest of the people with a small portion of the income these people are less concerned about the environment. For this reason trying to improve the environment can be difficult. An example would be some of the countries in the Middle East. Some of these countries have very high gross national income per capita but the actual bulk of the wealth is with a few select people. Trying to change the amount of pollution in these countries can be very difficult. In contrast to this, countries whose incomes are distributed fairly evenly across the population, if the income is adequate for these people, the demand for cleaner air is greater. Once this happens the demand to decrease the amount of pollution released into the air is increased. For each of these cases the gross national income for these countries could be the same and increase at the same rate. But if the environment is to be improved a large portion of the population must demand it.

Yandle, Bhattarai, and Vijayaraghavan (2004) give a reasonable insight to this in their paper, ***Environmental Kuznets Curves: A Review of Findings, Methods, and Policy Implication***, saying: "there is more to the improved environment story than rising income. Improvement of the environment with income growth is not automatic but depends on policies and institutions, GDP growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and makes the resources available for supplying it." (29) Once the demand for a cleaner environment is great enough, certain groups can enact policies that will help the environment.

Linking the possibility of the EKC being the result of counties importing pollution intense goods from other countries through international trade brings up the possibility of pollution haven countries. The pollution haven hypothesis basically states that countries with less stringent environmental policies will attract more pollution intense industries, causing their pollution levels to increase. Empirical work done by Antweiler, Copeland, and Taylor (2001) addresses the possibility of the pollution haven hypothesis. They state that "This paper investigates how 'openness' to international markets affects pollution levels to assess the environmental consequences of international trade." (877) Contrary to what one would logically think would happen, with the possibility of counties accumulating more industries, they found the opposite. For sulfur dioxide concentration, increases in trade actually reduced concentrations. (Antweiler, Copeland, and Taylor: 2001)

Most of the literature concerning the EKC and the effects of trade on the environment has been done using cross-sectional data for several different countries over several years. Deacon and Norman (2004), in their paper "Does the Environmental

Kuznets Curve Describe How Individual Countries Behave?" take a different approach to determining if the EKC hypothesis has weight. Their approach analyzes data for individual countries over a certain number of years, using income and pollution levels for each of the individual countries. (Deacon and Norman: 2004) They state that "We do this because the EKC purports to answer a within-country question: How will a nation's environmental quality evolve if it makes the transition from poverty to wealth?" I feel this approach is the best course to take to determine how an individual country will behave over time. Deacon and Norman (2004) do not use a variable to account for increases in income due to increases in trade. Given the number of countries they used in their study, if the pollution haven hypothesis is a valid explanation of the EKC, their results should concur with the EKC. Deacon and Norman found that most increases or decreases in some pollution levels could have occurred just as easily if they happened by chance.

One concern of some people who have done studies on the Environmental Kuznets Curve is whether if one country's amount of pollution decreases it is actually gained by another country. This could be the case when a country wishes to import goods that will be two expensive for them to produce for them selves if there are strict policies that enforce how clean the process is for making the product. Joseph E. Aldy states in his paper, ***An Environmental Kuznets Curve Analysis of U.S. State Level Carbon Dioxide Emissions***, "All countries cannot someday converge to a low carbon – intensity, advanced stage of development characterized by specialization in services and imports of carbon intensive goods from other countries. This certainly questions whether the inverted – U income emissions shape is permanent or only reflects the presumably temporary variation

in economic development across the world." (22) Strong evidence of this could possibly be found between the United States and Mexico. Since NAFTA, numerous jobs that where carbon dioxide intensive to make have moved to Mexico. The main driving force for this is labor cost. However, environmental policies in Mexico are less stringent than in the United States.

Using a within-country analysis to determine the relationship between pollution and income, I feel, is the most logical means of determining how a country should approach its environmental concerns. The same can be said for determining the pollution haven hypothesis. Kevin P. Gallagher in his paper "Economic Integration and the Environment in Mexico: Lessons for Future Trade Agreements" analyzes both the EKC and the pollution haven hypothesis for Mexico. He believes Mexico is an ideal location to test for these two hypotheses. Since Mexico started liberalizing its trade nearly twenty years ago and their national income level has reached a level that has been theorized as the turning point when pollution starts to decrease, if evidence of either hypothesis exist it should be easy to determine (Gallagher: 2004). In trying to determine if the EKC hypothesis holds true for Mexico Gallagher found little evidence to support it. He does offer that the actual turning point could be associated with a higher income. Also, the lower levels of pollution could be related to the use of more manual labor than pollution intense machines to run production (Gallagher: 2004). For the pollution haven hypothesis, his regression revealed no evidence that when the cost of controlling pollution in the U.S. increased there was an increase in new industry in Mexico (Gallagher: 2004). This could be attributed to the small factor environmental concerns play in the cost of production.

Cross sectional regression

When beginning my research of this topic I decided to use recent updated data that would hopefully be more accurate than earlier collected data. The CO2 per capita emissions data for different countries was obtained from the UNEP web site (United Nations Statistics Division). Some countries did not have data listed for 1999 or 2000 and were not included in my regression. The gross national income per capita was obtained from a data query of world development indicators from the World Bank Group web site.

Using these data sets, I was able to get 156 countries with corresponding CO2 per capita emissions and gross national income per capita for 1999 and 2000. With two years of data for 156 countries I had enough information to do a cross sectional regression.

The equation:

$$CO2=\alpha+\beta1*GNI+\beta2*GNI\text{^}2+\beta3*YEAR$$

Squaring the coefficient β2 gives an estimate of -1.87E-08, which shows support for the inverted U – shape described by the EKC hypothesis. This is a very simple regression that supports the EKC hypothesis more extensive empirical research concerning other types of pollutants (sulfur dioxide, particles, and smoke) have been done showing support for the EKC and determining at what levels of income pollution starts to decrease. (See Grossman and Krueger, 1995)

With-in Country Regression

To determine if the EKC should be used for policy decisions, I feel a closer look at the pollution - income relationship for individual countries is needed. With the implementation of NAFTA in 1994 between Mexico and the U. S., an analysis of with-in country relationships between pollution and GNI should display evidence for the EKC

hypothesis. This is due to Mexico's increasing wealth due to a stronger economy. One would expect to see evidence of Mexico reaching the turning point described by the EKC. The U.S. should show evidence of the negative relationship between income and pollution because of its higher wealth and due to an increasing amount of manufacturing industries moving to other countries including Mexico.

With-in Mexico regressions

Using per capita CO2 emissions for Mexico, from 1980 to 2000, related to GDP per capita should provide evidence of the EKC hypothesis. Running a simple linear regression will show if the relationship is positive or negative. Do to the low wealth of Mexico I expect there to be a positive relationship between them. Squaring the coefficient will help determine the nonlinear relationship. If the relationship is positive their will be an increasing positive relation ship between pollution and wealth. If it is negative this will give support for the EKC since it exhibits the inverted U-shape. It should be noted, studies done concerning with-in country analysis have shown little evidence for the EKC, but that each country may be on its own time frame concerning where it is located on the EKC (see Deacon and Norman, 2004).

For a measure of wealth for Mexico I have taken the Gross Domestic Product SA from Econstats.com from 1981 to 2000 and divided it by the population for each year, also obtained from Econstats.com. This allows for an acceptable measure of wealth per capita. The CO2 emissions were obtained from the same data set for the cross-sectional regression (UNEP web site: United Nations Statistics Division). Running two simple regressions, one for a linear relationship and one for a nonlinear relationship, should show support for or against the EKC.

Equation 1:

$$CO2=\alpha+\beta1*GDP$$

The OLS estimate for β1 is 9.69E-06. Even though this is a very small number it is still positive. To determine if the pollution income relationship for Mexico shows support for the EKC an equation for a nonlinear relationship is needed.

Equation 2:

$$CO2=\alpha+\beta1*GDP+\beta2*GDP^2$$

The result for the OLS estimate for β2 is -3.84E-10. Determining that the estimate is negative shows support for the inverted U-shape depicted by the EKC hypothesis. Most studies done concerning the EKC use Gross National Income per capita as their measure for income. This study is different, as I stated above, because GDP is used as the measure of wealth.

For the EKC hypothesis to apply to Mexico, for this relationship, it would be in contrast to the pollution haven hypothesis. If the results for the U.S. regressions show similar findings the possibility of pollution being transferred through trade may not be happening.

With-in U.S. regressions

The CO2 emissions used for this regression are the same ones used earlier in the cross-sectional regression from the UNEP web site: United Nations Statistics Division. For a measure of wealth I am using GNP per capita in current U.S. dollars from 1990 to 2001. These numbers were obtained from the U.S. Census Bureau, Statistical Abstract of the United States: 2004-2005. Examining the relationship between pollution and income

for the U.S. from 1990 to 2001 should show a negative relationship between the variables, considering the U.S. is one of the wealthiest countries in the world. However, individual countries behave differently. With such a short time span of data small fluctuations can occur. This regression could show evidence of a positive relationship or a negative one. The first regression is to determine if there is a negative linear relationship for income and pollution. Considering the high income of the U.S. the possibility of there being a negative linear relationship is possible if the EKC hypothesis holds true.

Equation 1:

$$CO2=\alpha+\beta1*GNI$$

The OLS estimate for β1 is 8.76E-05. This linear regression produced a positive estimate for income and pollution. This estimate should not be a definite model used to show support against the EKC hypothesis. Different pollutants can show different relationships with measures of income. CO2 is one of the most common pollutants to be produced. The turning point for CO2 could be in the future. The next regression will show the nonlinear relationship between CO2 and income and could offer some clues if the turning point could be in the future.

Equation 2:

$$CO2=\alpha+\beta1*GNI+\beta2*GNI\text{^}2$$

The OLS estimate for β2 is -8.94E-09. The estimate of a negative coefficient lends support for the EKC hypothesis. The turning point for the inverted U-shape pattern could possible be in the future for this relationship.

Using within country analysis to determine the existence of the EKC hypothesis has shown support for it. This is in contrast to the pollution haven hypothesis. To determine the possibility of the pollution haven hypothesis a comparison of economic indicators with CO2 emissions could offer evidence.

Comparisons of indicators

The pollution haven hypothesis can be connected to the EKC hypothesis when discussing how trade may effect the environment. Due to NAFTA, Mexico and the U.S. should offer the best case study to determine if the pollution haven hypothesis applies for these two countries, pollution decreasing in the U.S. and increasing in Mexico due to trade. A simple comparison of economic indicators to CO2 pollution emissions for Mexico could provide evidence of the pollution haven hypothesis. The economic indicators I use for Mexico are exports, industrial production, and manufacturing production. If the pollution haven hypothesis exist the time periods when trade increased between Mexico and the U.S. should have increased the level of some of these indicators. If levels of CO2 pollution increase as significantly, this could show evidence of Mexico increasing pollution due to trade.

Table 1:

Year	% Change Co2 Per Capita Mexico	Industrial Production % Change Mexico	Manufacturing Production % Change Mexico	Exports % Change
1991		3.90	3.40	4.90
1992	1.94	2.70	4.40	8.20
1993	-2.02	-2.00	0.30	12.30
1994	-1.34	4.10	4.80	17.30
1995	3.70	-4.80	-7.80	30.60
1996	9.40	11.00	10.10	20.70
1997	-1.45	9.70	9.20	15.00
1998	10.85	7.30	6.30	6.40
1999	-2.86	4.20	4.20	16.10

I have converted the data obtained for per capita CO2 emissions by multiplying each year's amount by that year's population. This allowed me to calculate an aggregate percent change for CO2 for the country in each year. The first notable observation to be discussed should be the changes in CO2 from year to year. NAFTA was started in 1994. If the pollution haven hypothesis holds true increases in CO2 should have occurred during those first couple of years and increase substantially. This is the case, from 1995 to 1996 pollution increased 9.40% and from 1997 to 1998 pollution increased 10.85%. In years before 1995 changes were moderately increasing or decreasing. This helps lend evidence for the existence of the pollution haven hypothesis.

Comparing industrial production % changes to CO2 % changes, the highest increases in production occurred after 1995 with 11.0, 9.7, and 7.3% increases for 1996,1997, and 1998. These increases occurred during the same time that CO2 pollution increased substantially.

Manufacturing production grew at similar rates to industrial production. Before 1996 manufacturing increased slow to moderately but after 1996 it increased 10.10% in 1997, 9.2% in 1998, and 6.3% in 1999. These increases also occurred during the same time frame when pollution levels increased.

Exports show the largest increases in growth of the three indicators I looked at. In 1994 exports grew at 17.3 percent and then in 1995 grew at its highest rate of 30.6%. Exports also increased by 20.7% in 1996 and 15% in 1997. There appears to be a moderate build up to 1994 then a drastic increase once NAFTA was initiated. These increases are during the same time frame that increases occurred in CO2 pollution for Mexico.

Findings

The cross-sectional regression I ran is a simple regression that shows support for the existence of the EKC hypothesis. I do not believe regression such as this should be used in policy making for individual countries. Earlier studies have shown that when countries reach a level of income in the neighborhood of 8,000 to 10,000 dollars their pollution levels start to decrease. The simple with-in country regressions I ran for Mexico and the U.S. do not show support for this level of income. Both countries exhibit the inverted U-shape of the EKC but neither has reached the turning point for CO2 pollution, which the linear regression supported. These regressions also did not provide much support for the pollution haven hypothesis. Both countries show positive relationships for the variables and continuing increases in CO2 pollution.

The strongest evidence I have found to support one of the hypotheses is for the pollution haven hypothesis. The comparative study between CO2 pollution increases and economic indicators for Mexico provided strong evidence that pollution has increased possibly due to trade. The dramatic increases in the indicators after 1994 and the increases in pollution after the same year are highly correlated with NAFTA. It can be stated that the increases in manufacturing and industrial production moving to Mexico from the U.S. could help cause the indicators and pollution levels to increase.

Even with the possible existence of the pollution haven hypothesis the nonlinear regression for Mexico does provide evidence that after a certain period of time and at a higher level of wealth pollution levels could start to decrease.

Personal Thoughts

One of the more interesting aspects of most empirical papers on the Environmental Kuznets Curve is how they tend to use the results from countries around the world to help solve the problems of individual countries. Each country has its own individual problems. When counties try to increase their national incomes they have to use the resources available to them. This works the same when a country tries to reduce the amount of pollution it creates. Even though there is empirical evidence to predict at what level of income a country will start to reduce its pollution, each country is individual and whether its pollution decreases or increases depends not totally on its income but what the people of the country desire.

Conclusion

The results of my research have helped me determine that both the EKC hypothesis and the pollution haven hypothesis can hold true depending on the situations countries find themselves in. But such studies should not be used to set policy standards for countries. There were large increases in CO2 emissions in Mexico after NAFTA was started. The evidence in this paper supports the possibility that these increases were the direct result of trade. Increases in industrial production and manufacturing production followed a similar pattern to pollution increases. The increases in exports due to free trade would have caused more people to move to the manufacturing centers of Mexico causing higher concentrations of pollution and the clearing of land for agriculture may contribute to higher levels of pollution.

The pollution haven hypothesis does not hold true for one aspect. CO2 concentrations for the U.S. continue to increase but at a rate that will eventually start to

decrease according to the with-in country analysis I ran. The same can be said for Mexico. Its levels of pollution will possibly start to decrease in the future. Only time will tell for both. One reason the with-in country regression for Mexico shows support for the EKC hypothesis could be the use of cleaner production methods to produce goods and services

Do to the limited knowledge I have of specific variables that can effect pollution levels from free trade continuing studies should be done to help countries understand how to increase their wealth while keeping levels of pollution acceptable.

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