INCOME, INEQUALITY, AND CRITERIA AIR POLLUTANTS IN THE CAMA COUNTIES

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Abstract

Socioeconomic factors have long been incorporated into environmental research to examine the effects of human dimensions on coastal natural resources. Boyce (1994) proposed that inequality is a cause of environmental degradation and the Environmental Kuznets Curve is a proposed relationship that income or GDP per capita is related with initial increases in pollution followed by subsequent decreases (Torras and Boyce, 1998). To further examine this relationship within the CAMA counties, the emission of sulfur dioxide and nitrogen oxides, as measured by the EPA in terms of tons emitted, the Gini Coefficient, and income per capita were examined for the year of 1999. A quadratic regression was utilized and the results did not indicate that inequality, as measured by the Gini Coefficient, was significantly related to the level of criteria air pollutants within each county. Additionally, the results did not indicate the existence of the Environmental Kuznets Curve. Further analysis of spatial autocorrelation using ArcMap 9.2, found a high level of spatial autocorrelation among pollution emissions indicating that relation to other counties may be more important to the level of sulfur dioxide and nitrogen oxide emissions than income per capita and inequality. Lastly, the paper concludes that further Environmental Kuznets Curve and income inequality analyses in regards to air pollutant levels incorporate spatial patterns as well as other explanatory variables.

Introduction

In 2008, 126 million people lived in counties within the U.S. where air pollution levels exceeded the primary quality standards (EPA, 2009). The Clean Air Act mandates the EPA set National Ambient Air Quality Standards (NAAQS) for pollutants deemed harmful to the public and environment. The EPA Office of Air Quality Planning and Standards (OAQPS) has set NAAQS for six primary pollutants, which are commonly referred to as “criteria” pollutants (EPA, 2009). The Coastal Area Management Act (CAMA) seeks to balance environmental concerns of North Carolina’s coast with economic development (NCDCM, 2009). The Coastal Resources Commission, created by CAMA, designates areas of environmental concern based on a variety of factors, including the existence of air pollution within the 20 CAMA counties (NCDCM, 2009). Some air pollutants, such as sulfur dioxide and nitrogen oxides, are of particular interest given their contribution to acid rain. Acid rain has deleterious effects on aquatic and non-aquatic biota, and its ramifications are felt throughout the coastal food web (EPA, 2008). Given that acid rain has a disproportionate effect on coastal waters, it is important to investigate relationships that exist with various factors and pollutants, such as sulfur dioxide and nitrogen oxides that contribute to acid rain (WHOI, 2009). In examining these pollutants, the possibility of the existence of an Environmental Kuznets Curve, an inverted U-shape pattern between income or GDP per capita and pollution levels (Torras and Boyce, 1998), is assessed as well as the effect of income inequality as measured by the Gini Coefficient.

Acid Rain: Environmental Effects

The environmental effects of acid rain are most pronounced in aquatic environments (EPA, 2009). Acid rain can decrease biodiversity and reduce or kill fish populations in streams, lakes, and marshes. As acid rain flows over soil aluminum leaches out, creating a toxic combination for fish. Although this may not always be lethal, it can create stress and lead to low body weight making the fish less of a competitor for food and habitat. More often, young are most susceptible to environmental stress (EPA, 2009). Since ecosystems are highly interdependent the pH level may indirectly hurt some organisms, which prey on organisms that die off due to a low pH level. A study by Chu and Hames (2002) examined birds laying defective eggs. Since the acidity did not appear to affect the bird directly, the food web was examined. The birds preyed on snails and other insects. The acid rain caused the snails to die off because they depend on calcium from the soil, which was leached out by the acid rain. The birds could no longer prey on snails and their diets became calcium deficient leading to the defective eggs (Chu and Hames, 2002). Acidification of water and soils can decrease biodiversity as some organisms are able to cope with the pH level and others cannot (EPA, 2008). Additionally, atmospheric deposition of nitrogen oxides has had a significant effect on estuaries and near-coastal water bodies. This atmospheric deposition has been found to contribute to coastal eutrophication. Jaworski et al (1997), found a strong linkage between the increase in nitrogen oxide emissions from fossil fuel combustion and the increase in eutrophication of the coastal waters of the Northeast United States.

Problems associated with eutrophication include algal blooms, loss of seagrass beds, loss of coral reefs, declines in the health of aquatic organisms, and ecological changes in food webs (EPA, 2009).

Socioeconomic Perspectives

It has been theorized that income or GDP per capita is related with initial increases in pollution followed by subsequent decreases (Torras and Boyce, 1998). This inverted U-shaped relationship is known as the Environmental Kuznets Curve. The increase in the pollution levels is thought to be due to the scale effect. The scale effect is due to an increase in output or production that is associated with an increase in income. As the income increases, two effects can occur. The first effect is caused by the movement out of sectors that are pollution intensive into alternative sectors. The second effect, is caused by the adoption of production strategies that create less pollution, whether government mandated or driven by technological advances (Torras and Boyce, 1998). In addition to the effects of income per capita on the level of pollution, it has been hypothesized that a greater level of inequality is linked with higher level of pollution (Boyce, 1994). The Gini coefficient is a measure of income inequality ranging from 0 to 1, with 0 being the most equal allocation and 1 being the most unequal. It has been theorized that greater power inequality, related to income inequality, lends itself to higher pollution levels. It is believed that those few with the most power would benefit from pollution causing activities while the powerless bear the costs. Additionally, individuals with higher income generally possess more assets and consume more. Therefore, they benefit from the surpluses created by pollution-creating production (Boyce, 1994).

Statement of the Problem

Given the literature on the Environmental Kuznets Curve and income inequality, the research hypothesis is that sulfur dioxide and nitrogen oxides emissions in tons exhibit an inverted U-shape with respect to income per capita and have a positive relationship with respect to the Gini Coefficient. Therefore, the null hypothesis is that income per capita and the Gini coefficient have no effect on the tons of these two criteria pollutants emitted.

Methods

Pollution measurements for nitrogen oxides and sulfur dioxide were obtained from the EPA's National Emissions Trends Database in terms of tons emitted during 1999 for each CAMA county. The per capita income for 1999 was obtained from the U.S. Census Bureau (U.S. Census Bureau, 2000). The 1999 Gini Coefficient for each CAMA county was also obtained. The relationships were analyzed, using multiple regression analysis in the statistical package SPSS 16.0, in order to discern if there is a statistically significant relationship between the variables. The variables were also mapped using ArcMap 9.3 to examine the possibility of spatial autocorrelation.

Quadratic Regression

Given the hypothesized inverted U-shape of the Environmental Kuznets Curve, it is typically thought of as a quadratic function and statistics regarding it utilize a quadratic regression. Therefore, two quadratic regressions were utilized with the following specifications:

$N = \beta_{1*}I^2 + \beta_{2*}I + \beta_{3*}Gini + \varepsilon$
$S = \beta_{1*}I^2 + \beta_{2*}I + \beta_{3*}Gini + \varepsilon$

Where S = sulfur dioxide percapita and N = nitrogen oxides per capita are measured in tons of pollutant emitted per county during 1999 normalized by the population per county as reported by the U.S. Census. I= income per capita as measured in dollars for 1999, and Gini is the Gini coefficient per county during 1999.

For nitrogen oxides, the results show that I (p= 0.014) and I^2 (p= 0. 017) are highly statistically significant, and Gini is not statistically significant. However, these specifications do not reveal an inverted- U shape as the Environmental Kuznets Curve would suggest, which would require a negative square term and a positive linear term. Overall fit the model explained over 42% of the variation (R^2 = 0. 424).For sulfur dioxide, the results show that I, I^2, and Gini are not statistically significant. The specifications do not reveal an inverted- U shape as the Environmental Kuznets Curve would suggest. Overall the model explained less than 25% of the variation (R^2 = 0.246).

Spatial Autocorrelation

Spatial autocorrelation was screened for by using Moran's I and the subsequent standardized Z score. For nitrogen oxides, there was a less than 1% likelihood that the levels were clustered by chance (Moran's I = 0.12, Z score =4.21 s.d.). For sulfur dioxide, there was a less than 5% likelihood that the pattern occurred by chance (Moran's I = 0.02, Z score =2.08 s.d.). Given the level of pollution of neighboring counties seems to be related to the level of pollution in other counties, the author recommends future studies focus on augmenting the conventional Environmental Kuznets Curve by spatially weighted values of the dependent and independent variables

Conclusions

In conclusion, acid rain has many anthropogenic causes from ships to industrial hog operations that are prevalent in the CAMA counties. Acid rain can have ill effects on the organisms in the aquatic habitat as well as on land. The CAMA counties did not exhibit the hypothesized inverted U-shape between the criteria pollutants per capita (NO_x and SO_2) and income per capita. This analysis does not prove nor disprove the Environmental Kuznets Curve, as the level of income within the CAMA counties may not have varied enough to show the full range of the Environmental Kuznets Curve. Also, omitted variable bias may have affected the analysis, as three explanatory economic variables were not sufficient to capture the entire relationship. Additionally, the level of income inequality was found to be statistically insignificant to the level of the examined air pollutants. For future studies, I recommend increasing the sample size and changing the scale to state or country level data. Based on the findings, the author recommends further analysis on the Environmental Kuznets Curve and income inequality and their relation to air pollutants take into account spatial patterns. Although the exact relation between the human dimension and pollution levels of coastal counties is unknown, humans are undoubtedly an integral part of the coastal ecosystem.

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