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AN EMPIRICAL ANALYSIS OF THE INTERACTIONS BETWEEN ENVIRONMENTAL REGULATIONS AND ECONOMIC GROWTH

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Abstract:

The purpose of this research is to examine the relationship between environmental regulation and economic growth. A four-equation regional growth model is used to analyze the simultaneous relationships among changes in population, employment, per capita income, and environmental regulations for the 410 counties in Appalachia. Our results reveal that initial conditions for environmental regulation are negatively related to regional growth factors of change in population, per capita income, and total employment. From this, we infer that the diversion of resources from production and investment activities to pollution abatement is inadvertently transmitted to other sectors of the economy—thereby resulting in a slow-down of regional growth. We also find robust evidence that show that changes in environmental regulations positively influence changes in population, total employment, and per capita income. Thus, we parsimoniously conclude that in the long-run, environmental regulations are not detrimental to economic growth.

Key Words: Environmental regulations, economic growth, regional growth model, Appalachia

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1. Introduction

Following the passage of the Clean Air Act [CAA] in 1970[3], there have been heated debates on the economic impacts of U.S. air quality regulations (Denison, 1979; Portney, 1981; Bartik, 1985; Barbera and McConnell, 1986; Christainsen and Haveman, 1981). Despite extensive study and debate, the relationship between environmental regulations and economic growth is still not well understood. While several researchers including, List and Co (1999), Gray and Shadbegian (1993), and Fredriksson and Millimet (2002a) find evidence that environmental regulations negatively affect economic growth, Porter (1991) and Porter and van der Linde (1995) argue that environmental regulations stimulate technological innovation and this, subsequently leads to industrial growth. This view is known as the Porter hypothesis.[4]

Moreover, the focus of earlier studies has been exclusively on affected industries in the manufacturing sector (Duffy-Deno, 1992; Jaffe and Palmer, 1996; List and Co, 1999). The justification for this is that many of the environmental policies are directed at manufacturing industries, and therefore, aggregate changes in employment, firm expansion or contraction will directly affect polluting firms (Bartik, 1985). However, manufacturing is not isolated from the rest of the national economy and as such, the effects of environmental regulations on manufacturing industries may have spin-off effects on other sectors of the economy which supply goods and services to the manufacturing sector, and consequently affect the pattern of regional growth. To reinforce this view, Yandle (1985, p. 39) points out that the "effects of

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[3] The 1970 Clean Air Act set National Ambient Air Quality Standards [NAAQS] for six major air pollutants: tropospheric ozone (O_3), total suspended particulates (TSP), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb). The CAA was first amended in 1977 and later in 1990.

[4] The Porter hypothesis could work because firms complying with state and local environmental regulations will invest in new capital equipment that improve productivity and at the same time help reduce emissions of pollutants. An improvement in air quality has an amenity value and that may also affect the pattern of economic growth (Van, 2002; Grossman and Krueger, 1995).

environmental regulations go far beyond the physical plant closings and worker layoffs" and that the regional concentration of polluting industries may affect regional development.

From the foregoing discussion, it is clear that the impact of environmental regulation on economic growth remains an open question. Cole et al. (2006) assert that this is because environmental regulations have been treated as exogenous. In the same breath, Fredriksson and Millimet (2002b) and Condliffe and Morgan (2009) note that the variables used as proxies for environmental regulations introduce endogeneity bias in the estimation. This is because environmental regulations can be endogenously determined by a number of factors such as income, population, and employment change, including other socio-economic factors. This suggests that an accurate representation in an econometric model must account for simultaneity between environmental regulation and economic growth.

To this end, one unexplored area in the empirical literature is the use of structural equations in estimating the environmental regulations-economic growth relationship. The analyses presented in this study assume that environmental regulations are endogenous and are jointly determined with per capita income, population, and total employment. Specifically, the purpose of this research is to address a number of questions that have arisen concerning the relationship between environmental regulation and economic growth. The questions are: to what extent does environmental regulation influence regional growth patterns, and conversely, to what extent do regional factors influence environmental regulations?

To address these questions, unlike in previous research, we assume that simultaneous interactions exist among county changes in environmental regulations, per capita income, population, and total employment. Thus, total employment, per capita income, population, and environmental regulations are treated as endogenous variables and are specified in a four-equation regional growth simultaneous model. We employ county attainment status of the National Ambient Air Quality Standards [NAAQS][i] as a proxy for environmental regulations, and allow the cross-sectional variation of the attainment variable.

The motivation for specifying a four-equation simultaneous model is straightforward: 1) assuming that environmental quality is a normal good, ceteris paribus, individuals with higher incomes will support more stringent environmental regulations—thus, we hypothesize that higher incomes positively influence environmental regulations; 2) changes in population and industry concentration, including other firms' rent seeking activities will result in changes in environmental quality. Thus, it is reasonable to conclude that changes in population and total employment will positively influence the stringency of environmental regulations; and 3) enforcement of environmental regulations will result in improved environmental quality and make a location more attractive for households and businesses. This means that environmental regulations may positively influence population growth, income growth, and employment growth and vice versa.

This study contributes to the current discussion on economic impacts of environmental regulation by using a regional growth model that takes into account the interdependences among changes in environmental regulations, population, total employment, and per capita income at the county-level in the Appalachian Region. In order to account for state differences in growth patterns and environmental regulation implementation, we include state dummy variables in our empirical model. The second contribution of this study is that the empirical analyses are extended beyond firms and industries affected by environmental regulations.

The remainder of the paper is organized as follows. Section 2 provides the analytical framework for modeling the relationship between environmental regulations and growth, while section 3 presents data sources and types. Finally, sections 4 and 5 present the results and conclusions, respectively.

2. Analytical Framework

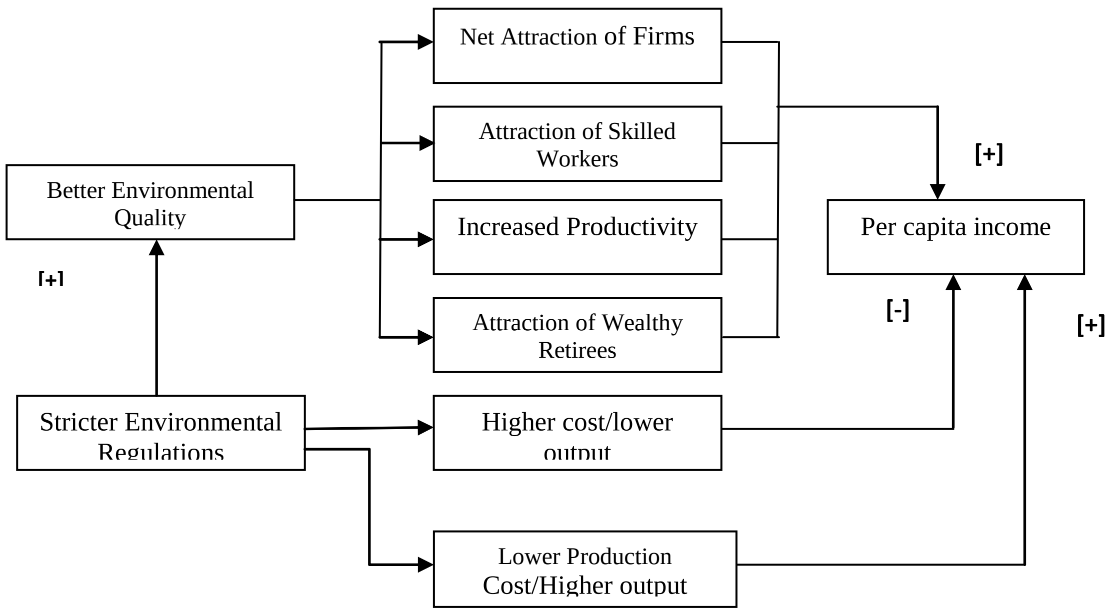
Within the context of the environmental Kuznets curve literature, factors such as population density, income, industrial composition, and other socio-economic indicators have been found to be influence the level of environmental pollution. This argument implies that factors that influence the level of pollution also have a bearing on environmental regulation stringency. From the concepts of utility and profit maximization, it is conceivable that consumers and firms will respond to spatial variations in environmental quality[5] (due to differences in environmental regulation stringency) and this may consequently affect the equilibrium levels of population, employment, and income growth rates across regions. These stylized facts are shown in figure 1.

According to figure 1, when environmental regulations are imposed, firms in the short-run will incur higher production costs due to investments in abatement technologies. Accordingly, the diversion of resources from production and investment activities will lead to slower economic growth in terms of per capita income and employment growth. Another fact underlying figure 1 is that in the long-run, environmental regulations enable firms to improve a jurisdiction's air quality and allow firms to reduce the marginal cost of pollution control and production, respectively. Therefore, we parsimoniously infer that the long-run gain of environmental regulations is reduced production cost for regulated firms and improved environmental quality. In the aggregate, environmental regulations have multiplier effects in

[5] Hosoe and Naito (2006) find evidence that variations in environmental regulation implementation among and within states have significant impacts on the mobility of capital and other resources across local jurisdictions. Similarly, the amenities literature show that an improvement in environmental has amenity value, which in turn helps to attract workers, businesses and wealthy retirees (Van, 2002; Grossman and Krueger, 1995; Goetz, 1996).

terms of attracting new firms, skilled workers, and wealthy retirees—and this also translates into increased per capita income for a given jurisdiction.

Figure 1: Long-Run Relationship between Environmental Regulations and Regional Growth



Modified version of Goetz et al. (p. 99, 1996)

To understand the above economic impacts of environmental regulations from a regional perspective, we extend Deller et al.'s (2001) model by specifying a four-equation simultaneous regional growth model. We assume that there is a lag-adjustment process between a change in one of the endogenous variables and the other endogenous variables. In a general equilibrium framework, population, employment, income, and environmental regulations are not only interdependent, but will also interact with exogenous factors, including the lagged values of the other endogenous variables.

The general form of the four-equation simultaneous model representing the interactions among population (P), employment (E), income (Y), and environmental regulations (ER) are specified as:

(1) $P^* = \alpha_{0P} + \beta_{1P}E^* + \beta_{2P}Y^* + \beta_{3P}ER^* + \sum \delta_{IP}\,\Omega^P$

(2) $E^* = \alpha_{0E} + \beta_{1E}P^* + \beta_{2E}Y^* + \beta_{3E}ER^* + \sum \delta_{IE}\,\Omega^E$

(3) $Y^* = \alpha_{0Y} + \beta_{1Y}P^* + \beta_{2Y}E^* + \beta_{3Y}ER^* + \sum \delta_{IY}\,\Omega^Y$

(4) $ER^* = \alpha_{0ER} + \beta_{1ER}P^* + \beta_{2ER}Y^* + \beta_{3ER}E^* + \sum \delta_{IER}\,\Omega^{ER}$

Where P^*, E^*, Y^*, and ER^* represent equilibrium levels of population, employment, per capita income, and environmental regulations, respectively in the ith county; $\Omega^P, \Omega^E, \Omega^Y$, and Ω^{ER} represent a set of exogenous variables that have either a direct or indirect effect on population, employment, income, and environmental regulations. Equations (1) through (4) state that equilibrium levels of population, employment, income, and environmental regulations depend on actual population, employment, income, and environmental regulations, including other exogenous variables in Ωs.

It is assumed that endogenous variables are not fully adjusted and that the endogenous variables adjust to equilibrium levels with substantial lags (Mills and Price, 1984). Following this relationship, the distributed partial adjustment models for the equilibrium levels for population, employment, income, and environmental regulations are specified as:

(5) $P_t = P_{t-1} + \lambda_P(P^* - P_{t-1})$

(6) $E_t = E_{t-1} + \lambda_E(E^* - E_{t-1})$

(7) $Y_t = Y_{t-1} + \lambda_Y(Y^* - Y_{t-1})$

(8) $ER_t = ER_{t-1} + \lambda_{ER}(ER^* - ER_{t-1})$

The subscript $(t-1)$ refers to the initial conditions of the endogenous variables, which in this case are the 1992 values; $\lambda_P, \lambda_E, \lambda_Y$, and λ_{ER} represent the speed-of-adjustment coefficients to desired levels of population, employment, per capita income, and environmental regulation. Adjustment coefficients are assumed to be positive and between zero and one. Equations (5) through (8) show that current employment, population, income, and environmental regulations are dependent on their initial conditions and on the change between equilibrium values and on its lagged values.

After rearranging equations (5) to (8), the change in population, employment, income, and environmental regulation equations are written as:

(9) $$\Delta P = P_t - P_{t-1} = \lambda_P(P^* - P_{t-1}) => P^* = \frac{1}{\lambda_P}(P_t - P_{t-1}) + P_{t-1}$$

(10) $$\Delta E = E_t - E_{t-1} = \lambda_E(E^* - E_{t-1}) => E^* = \frac{1}{\lambda_E}(E_t - E_{t-1}) + E_{t-1}$$

(11) $$\Delta Y = Y_t - Y_{t-1} = \lambda_Y(Y^* - Y_{t-1}) => Y^* = \frac{1}{\lambda_Y}(Y_t - Y_{t-1}) + Y_{t-1}$$

(12) $$\Delta ER = ER_t - ER_{t-1} = \lambda_{ER}(ER^* - ER_{t-1}) => P^* = \frac{1}{\lambda_P}(P_t - P_{t-1}) + P_{t-1},$$

Δ represents change in population, employment, income, and environmental regulations, respectively. The changes in the endogenous variables are derived from the difference between the 2007 observations and 1992 observations. Substituting equations (9) through (12) into the right-hand side of equations (1), (2), (3), and (4), respectively, we eliminate the right hand unobservable equilibrium values and obtain the econometric model to be estimated. The proposed empirical model consists of a system of four simultaneous equations describing population, employment, per capita income, and environmental regulation changes, respectively.

(13) $$\Delta POP = \alpha_{0P} + \beta_{1P}POP_{1992} + \beta_{2P}Y_{1992} + \beta_{3P}ER_{1992} + \beta_{4P}\Delta EMP + \beta_{5P}\Delta Y + \beta_{6P}\Delta ER + \beta_{7P}\text{DUM} + \sum \delta_{IP}\,\Omega^P + \mu_1$$

(14) $$\Delta EMP = \alpha_{0E} + \beta_{1E}EMP_{1992} + \beta_{2E}POP_{1992} + \beta_{3E}ER_{1992} + \beta_{4E}\Delta POP + \beta_{5E}\Delta Y + \beta_{6E}\Delta ER + \beta_{7E}\text{DUM} + \sum \delta_{IE}\,\Omega^E + \mu_2$$

(15) $$\Delta Y = \alpha_{0Y} + \beta_{1Y} EMP_{1992} + \beta_{2Y} Y_{1992} + \beta_{3Y} POP_{1992} + \beta_{4Y} ER_{1992} + \beta_{5Y} \Delta POP + \beta_{6Y} \Delta EMP + \beta_{7Y} \Delta ER + \beta_{8Y} \text{DUM} + \sum \delta_{IY} \Omega^{Y} + \mu_{3}$$

(16) $$\Delta ER = \alpha_{0ER} + \beta_{1ER} Y_{1992} + \beta_{2ER} POP_{1992} + \beta_{3ER} ER_{1992} + \beta_{4ER} \Delta P + \beta_{5ER} \Delta Y + \beta_{6ER} \Delta E + \beta_{7ER} \text{DUM} + \sum \delta_{IER} \Omega^{ER} + \mu_{4}$$

The dependent variables ΔPOP, ΔEMP, ΔY, and ΔER denote county changes in population, employment, per capita income, and environmental regulation, respectively; where μ_1, μ_2, μ_3, and μ_4 represent the structural error terms, Ω is a vector of exogenous variables, and DUM is a vector of 13 state dummy variables. [6] As already discussed, the lag adjustment models assume that the endogenous variables do not adjust instantaneously to their equilibrium levels but rather over a period of time. Deller et al. (2001) point out that the speed of adjustment to equilibrium levels is embedded in the coefficients α, β, and δ. Therefore, equations (13) to (16) estimate the short-term adjustments of population, employment, income, and environmental regulations to their long-term equilibrium levels of (P^*, E^*, Y^*, and ER^*).

3. Data

The study area is confined to the 410 counties of the Appalachian Region, which includes all of West Virginia and parts of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. The data covers the years 1992 to 2007 (Appendix 1). The dependent variables used in the models are measured as absolute changes in population, employment, income, and environmental regulations (1992-2007). County-level data for population, employment, and income are obtained from the Bureau of Economic Analysis, Regional Economic Information System

[6] 13 state dummy variables are included as explanatory variables to capture the effect of state differences in environmental regulation implementation and to capture the state influence on economic growth.

(REIS) and County and City Data Book (C&CDB) covering the years 1992 to 2007. County attainment status is used as a proxy for environmental regulation stringency and the data is obtained from the Federal Code of Regulations, Title 40, part 81, subpart C, covering the years 1992 to 2007.

Attainment status of a county is an appealing proxy for environmental regulation stringency because air quality problems result from stationary pollution sources such as power plants, factories, farming, heating of buildings, as well as cars, buses, and other mobile sources. Together, these sources represent production and consumption activities that contribute to environmental degradation. It can also be argued that county attainment status is an appropriate measure for environmental regulation stringency because its enforcement is felt by the county's households and firms; therefore, the analysis of such impacts must be made at county-level (Greenstone, 2002).

Given that a county can be out-of-attainment with respect to several air pollutants, the environmental regulation variable is an index of the total number of pollutants for which a county is out-of-attainment. The environmental regulation index is constructed using Henderson's (1997) methodology of summing the number of criteria pollutants a county is out-of-attainment. The criteria pollutants considered are ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), lead (Pb), and total suspended particulates (TSP). Following Henderson (1997) and List (2001), the attainment variable takes on values from 0 (cleanest county and least regulated) to 5 (dirtiest and most regulated)—and generally depends on the number of pollutants the county is out-of-attainment. For example, a county in attainment for five criteria pollutants takes on a value of 0, whereas a county out-of-attainment in all five criteria pollutants will be coded 5. With regard to the ozone standard, when part of the county has not met the complete federal ozone standard, the EPA assigns to these counties partial attainment or non-attainment status. For this reason, counties which are in partial attainment are coded ½.

A number of explanatory variables are included to explain changes in population, employment, income, and environmental regulations. Table 1 presents the exogenous and endogenous variables used in the models, along with the summary statistics. County level data on per capita income taxes, property taxes, unemployment rates, education levels, median housing values, percent of population below poverty line, and per capita local government expenditures are included to capture county characteristics that may affect growth. Other control variables that may explain growth are number of county manufacturing establishments (MFG), metro counties, percentage of population who are active in and retired from the labor force, and road infrastructure. Amenity variables (*AMEND*) are also included in order to capture their impact on population, employment, and income growth, respectively.

Determinants of changes in environmental regulations are captured by community activism (Sierra Clubs), growth factors, Democratic Party control,[7] percentage of population driving to work, percentage of black population, and unemployment rate. Other control variables that may explain changes in environmental regulations are population density, percentage of population with a bachelor's degree, percentage of population employed in manufacturing, percentage of population who are susceptible to suffer from environmental exposures, and the congestion that comes from metro counties.

4.

[7] Previous studies show that the stringency of U.S. environmental regulations is influenced by the political party that controls the executive branch and legislature (Lynch, et al. 2004; Regens et al., 1997). In particular, the Democratic Party is considered to be more supportive of stringent environmental regulations than the Republican Party. In the same vein, the Democratic Party is considered to pursue policies that are more pro-employment (Levitt and Porteba, 1994). As such, we also use the Democratic Party variable to explain changes in employment and per capita income.

5. **Empirical Results and Analyses**

The focus of this study is on the relationship between environmental regulations and economic growth. Table 1 presents estimated coefficients of the equations based on three-stage least squares (3SLS) estimation. The regression results reported exclude state dummy variables.[8] Based on the adjusted R^2 statistics, the estimated models explain 48 percent, 55 percent, 43 percent, and 62 percent of variations in changes in population, employment, per capita income, and environmental regulations, respectively.

4.1 Change in Population Equation

Except for environmental regulations, all the initial conditions have a strong effect on population growth and have the expected signs. Consistent with theory, results indicate that initial conditions of population, employment and income play an important role in determining population growth in the Appalachia. Notably, the coefficient estimate for the initial condition of population (*POP92*) has a negative sign and is significant at 1 percent level. This finding confirms the convergence hypothesis—which suggests that Appalachian counties which had initial high levels of population tend to experience a lower absolute growth rate than counties which had low levels of population in the initial period.

Another important variable that deserves attention is the change in environmental regulations. Table 1. shows that the coefficient estimate for change in environmental regulations (*ENREGCH*) has a positive impact on change in population and is statistically significant at the 10 percent level. One possible explanation may be that stringent environmental regulations result

[8] Complete results with state dummy variables are shown in appendix 2. Overall, results indicate that interstate differences in environmental regulation implementation and economic policies differentially and systematically influence environmental regulation outcomes and the pattern of regional growth, respectively.

Table 1: Three Stage Least Squares Results for Appalachian Region

Variable Name	ΔPopulation		ΔEmployment		ΔPer Capita Income		ΔEnvironmental Regulation	
	Coefficient	ρ Value	Coefficient	ρ Value	Coefficient	ρ Value	Coefficient	ρ Value
Endogenous Variable								
EMPCH	2.081	0.000	-	-	0.040	0.006	0.054	0.374
POPCH	-	-	0.451	0.000	0.014	0.742	0.004	0.052
PCICH	1.885	0.002	2.160	0.000	-	-	0.062	0.000
ENREGCH	0.843	0.015	0.520	0.000	0.138	0.000		
Initial Conditions								
EMP92	0.639	0.003	−0.064	0.000	-	-	-	-
POP92	−0.148	0.000	1.092	0.000	0.060	0.002	0.002	0.016
PCI92	-	-			−0.382	0.000	0.041	0.025
ENREG92	−0.032	0.104	−0.086	0.000	−0.741	0.000	0.676	0.000
Economic Variables								
PROPTAX	−36.747	0.186	−7.376	0.575				
MFG	−6.562	0.714	22.705	0.010	−7.019	0.057	0.007	0.038
MFGEMP	-	-					0.003	0.478
UNEMP	−211.173	0.037	−96.683	0.142				
POVRATE	-	-			−85.830	0.007	0.008	0.000
PCTAX	3.079	0.191	2.451	0.114	−1.778	0.094	-	-
MHVAL	−0.008	0.793	-	-	-	-	-	-
LGEXP	1.290	0.004	0.701	0.004	34.126	0.228	-	-
Human Capital and Demographic Variables								
ACTIVE	-	-	-	-	37.907	0.172	-	-
DEGREE	-	-	14.536	0.541	11.818	0.006	0.002	0.000
POPDEN	-	-	-	-	-	-	0.003	0.001
RISK	-	-	-	-	-	-	0.008	0.001
RETIRE	-	-	-	-	−39.729	0.000	-	-
BLACK	-	-	-	-	−128.570	0.0807	0.001	0.000
Locational Variables								
METRO	8401.985	0.000	−2611.31	0.065	-	-	−0.251	0.000
ROADDEN	2329.112	0.570	606.332	0.785	-	-	0.124	0.002
CRIME			0.017	0.834	-	-	-	-
Environmental Quality Variables								
AMEND	1760.273	0.001	−764.216	0.004	863.853	0.151		
VOTE	-	-	0.650	0.969	99.825	0.043	0.003	0.000
SIERRA	-	-	-	-	-	-	0.023	0.006
POPDRIVE	-	-	-	-	-	-	0.004	0.000
Constant	9013.233	0.001	7389.01	0.020	0.591	0.005	0.528	0.000
Adj. R^2	0.483		0.5580		0.4318		0.625	
Sample Size	410		410		410		410	

in improved environmental quality and thus make local areas more attractive for businesses and households. From a neoclassical standpoint, this implies that utility maximizing individuals will migrate to areas with better environmental quality. By direct contrast, the initial condition for environmental regulations is negative. This result is consistent with the idea that before firms adopt air pollution abatement technologies a county's air quality is poor and this phenomenon will discourage population growth.

The coefficient for change in employment (*EMPCH*) is positive and significant in the population equation. This suggests that county employment growth (or an increase in labor demand) stimulates population growth. This finding is consistent with the jobs-follow-people hypothesis (Steinnes and Fisher, 1974). Also, the role of per capita income change (*PCICH*) in explaining growth in population is strong, as reflected by the magnitude and positive sign of the coefficient (significant at the 5 percent level).

Generally, high unemployment rates indicate economic distress and a dearth of employment opportunities, and this relationship is reflected by the negative coefficient on unemployment rate. The coefficient for metropolitan county (*METRO*) is positive and statistically significant at the 1 percent level. This finding reinforces the notion that metropolitan counties have an array of economic activities which promote agglomeration economies, and this may have a pull-effect on population.[9] The regression analysis also reveals a significant positive relationship between the amenities index (*AMEND*) and population growth. These findings are consistent with results from previous studies (McGranahan, 1999; Deller et al., 2001).

[9] Data from the 2000 United States census indicate that about 57 percent of Appalachian residents lived in metropolitan counties, compared to 80 percent of the U.S. residents.

4.2 Change in Employment Equation

The estimated results for the change in employment equation are shown in column 3 of table 2. The initial condition for employment (*EMP92*) has a statistically significant and negative effect on employment growth. The implication of this finding is that counties with initial low employment levels in the 1990s are experiencing faster growth in employment than counties which had high initial levels of employment. These results are consistent with findings from previous studies (Gebremariam et al., 2007; Black et al., 2007) about the convergence in employment rates in the Appalachian region. Black et al. (2007) attribute the convergence of employment in Appalachia to the wide diversification of the Appalachian economy. Accordingly, this diversification has resulted in the growth of the service sector, retail sector, and growth in government employment.

The estimated coefficient on initial conditions for population (*POP92*) is statistically significant and positive, thus supporting the hypothesis that people follow jobs. An increase in population entails a larger supply of labor. The positive effect of population on employment growth is supported by evidence from the Appalachian Regional Commission which shows that between 2002 and 2004, there was a large growth of employment in Appalachia as well as in the nation as a whole.[10] Therefore, it is surmised that the increase in population did not diminish employment opportunities, but rather was necessary to meet the increasing demand for labor.

As expected, initial environmental regulations (*ENREG92*) have a negative and statistically significant effect on employment growth. The plausible explanation for this negative correlation is that, following the designation of counties as attainment or non-attainment in 1990, the EPA required states to submit state implementation plans (SIPs) at the end of 1992.

[10] See Appalachian Region Employment Report on http://www.arc.gov/images/appregion/AppalachianRegionEmploymentReport2009Q2.pdf

Therefore, between 1990 and 1992 polluting firms faced stringent standards with regard to pollution control and thus shows that stringent environmental regulations negatively affect employment growth in the initial years of implementation due to the fact that polluting firms have to install expensive pollution abatement control equipment. The effect of this may inadvertently be transmitted to other sectors of the economy, thereby resulting in the overall slow-down of total employment growth.

On the other hand, the coefficient on the change in environmental regulations (*ENREGCH*) is positive and statistically significant at the 1 percent level. These results underscore the Porter hypothesis by indicating that firms' marginal costs of abatement and production may decrease over time as firms invest in efficient technology. The efficient technology firms invest in serves the dual role of improving productivity and enhancing environmental quality, such that areas with better environmental quality become important locations for business investment.[11] These finding are consistent with previous studies (Goetz et al. 1996; Porter and van der Linde, 1995; Ringquist, 1993) in revealing that the short-run effects of environmental regulation are reduced employment growth, but in the long-run environmental regulation positively influences employment growth.

Also, the coefficient on the change in population (*POPCH*) is statistically significant at the 1 percent level and is positively related to employment growth. This finding, again, confirms the "people-follow-jobs" hypothesis of Steinnes and Fisher (1974). Similarly, a change in per capita income (*PCICH*) is statistically significant at the 1 percent level and is positively related to employment growth. This means that Appalachian counties with high income experienced

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[11] If we assume that an improvement in environmental quality has an amenity value, it is expected that firms and individuals will migrate to these regions, thereby stimulate growth in employment.

increased growth in employment. This could be attributed to the economy-wide diversification that has taken place in the Appalachia.

4.3 Change in Per Capita Income Equation

Three stage least squares regression results for the change in per capita income equation are reported in column 4 of table 2. The sign and level of significance for the initial condition for environmental regulation (*ENREG92*) mirrors results obtained in the employment and population equations (negative and significant at the 1 percent level). The initial conditions for environmental regulations intuitively mean that an area's environmental quality is poor, and this has the effect of discouraging capital and labor migration. Therefore, in order to bring the air quality into compliance with federal standards, firms in non-attainment counties invest in pollution abatement technologies. Investments in the initial period result in increased production costs and reduced output, hence reducing labor demand. Because of the spinoff effects, other sectors of the economy will also be negatively affected and consequently reduce growth in per capita.

Except for the change in population (*POPCH*) variable, all endogenous variables are significant in explaining growth in per capita income. Economic theory shows that growth in employment (*EMPCH*) results in an increase in aggregate labor demand, and as a result, higher per capita income. The variable *EMPCH* has the expected positive sign and is significant at the 5 percent level. These findings provide empirical evidence of the hypothesized positive impact of employment growth on per capita income growth.

The estimated coefficient for change in environmental regulations (*ENREGCH*) is positive and statistically significant at the 1 percent level. This finding is consistent with the amenities literature which shows that an improvement in air quality positively influences per capita income growth (Grossman and Krueger, 1995; Goetz et al., 1996). To this end, we parsimoniously interpret the initial conditions of environmental regulations as the short-run effects of environmental regulations due to the fact that in the initial period, firms in non-attainment regions invest in pollution abatement technologies. By contrast, we interpret the change in environmental regulations as long-run effects.

Consistent with theory, an increase in local tax per capita (*PCTAX*) has a negative effect on per capita income growth, because taxes are an additional cost to individuals. Thus high tax counties will become unattractive locations for households. Regression results show that the percent of population below the poverty level (*POVRATE*) is inversely related to per capita income growth. The coefficient for poverty rate (*POVRATE*) is significant at the 5 percent level. The estimated coefficient for manufacturing establishment (*MFG*) shows a negative relationship with per capita income growth and is only significant at the 10 percent level. Perhaps the logical explanation for this negative correlation may be that manufacturing's role in the Appalachian region has evidently declined over the years, to the extent of reducing its contribution to per capita income growth and gross state product in general.

Again, the Democratic presidential candidate (*VOTE*) variable is included to capture political party influence on economic growth. The hypothesis that Democratic Party control is associated with increased economic growth is confirmed, based on the positive and significant coefficient for *VOTE*. Similarly, location attributes, such as amenities (*AMEND*) are positively related to income growth, but its coefficient is insignificant. The coefficient for the percentage of population with a bachelor's degree or above (*DEGREE*) is positive and significant, providing support for the positive relationship between human capital skills and income growth.

The percentage of population between 18 years and 64 years (*ACTIVE*) is used to indicate the demographic group that is typically considered to be in wage and salaried employment. The coefficient for *ACTIVE* has the correct positive sign, but is insignificant. By contrast, an increase in the percent of population 65 years and older (*RETIRE*) is negatively related to per capita income growth. This suggests that counties experiencing an increase in the population whose main source of income is social security and other retirement income are unlikely to experience income growth. Another demographic variable related to income growth is the percent of Black population (*BLACK*). The coefficient for *BLACK* is negative and significant at the 10 percent level. These findings are realistic in view of the fact that majority of the black population in the Appalachia live in the southern and central counties.[12] By all standards, the Appalachian Regional Commission considers the southern and central counties of Appalachia to be the most economically distressed region in the Appalachia.

4.4 Change in Environmental Regulations Equation

Estimated results for the environmental regulations equation are presented in column 4 of table 2. The estimated coefficient for 1992 environmental regulations (*ENREG92*) is positive and statistically significant at the 1 percent level. One explanation for this positive coefficient is that counties which are out-of-attainment in the initial period are likely to attract regulatory attention and thus positively influence changes in environmental regulations. This is in view of the fact that some counties will be out-of-attainment in a number of pollutants.

Initial condition for population (*POP92*) is positively related to change in environmental regulation and is significant at the 1 percent level. This finding illustrates that air pollution varies with population and therefore, an increase in population will positively influence environmental

[12] Young et al. (2007) examine the relationship between race and economic growth using county level data on per capita income, socioeconomic, and demographic factors for Mississippi. They find evidence that indicate that an increase in percentage of Black population is negatively related to income growth.

regulations stringency. However, the magnitude of the population coefficient is very small. The coefficient for the 1992 per capita income (*PCI92*) is positive—reinforcing the hypothesis that an increase in income increases the demand for environmental quality, assuming that environmental quality is a normal good. The variable for change in per capita income (*PCICH*) has a positive effect on environmental regulation change (table 2), lending support to the theory that at high income levels, the policy response towards environmental degradation is stronger. While the coefficient for population change (*POPCH*) is negative and statistically significant at the 10 percent, the coefficient for change in employment (*EMPCH*) fails to attain any statistical significance.

The EPA considers children below 5 years and adults above 65 years to be particularly sensitive to exposure to air pollutants. The percentage of the population who are considered sensitive (*RISK*) to environmental exposures has the expected positive sign. *Ceteris paribus*, an increase in the proportion of the sensitive group of people will result in an increase in the demand for stringent environmental regulations. Conceivably, community/public activism towards environmental issues will not only emanate from the population that is susceptible to illnesses due to environmental exposure, but will also come from environmental pressure groups, such as the Sierra Club and others. The coefficient estimate for Sierra Club (*SIERRA*) is positive and significant at the 5 percent level. These results provide evidence that environmental pressure groups are pro-environment and will exert pressure on regulatory agencies for enforcement of stringent environmental regulations.

Previous studies also show that the stringency of U.S. environmental regulations is influenced by the political party that controls the executive branch and legislature (Hay et al. 1996; Lynch, et al., 2004; Regens et al., 1997). Accordingly, the percent of votes cast for the

Democratic Presidential candidate (*VOTE*) appears to have a positive influence on environmental regulations outcomes. This finding is in accord with Kahn and Matsusaka's (1997) finding that Democratic Presidential voting patterns explain environmental outcomes. Additional information on the support for environmental regulation is provided by the positive and significant coefficient for proportion of population with a bachelor's degree (*DEGREE*). These findings suggest that counties featuring high levels of college graduates are more prone to support stringent environmental regulations and are likely to lobby effectively against pollution (Hackett, 2001; Kahn, 2008).

Population density (*POPDEN*) and percentage of population driving to work (*POPDRIVE*) are included as explanatory variables to control for the congestion externalities. The coefficients for population density and percentage of population driving to work are positive as shown in table 2. This follows because a dense population entails increased economic activity and also increased vehicular traffic, which both translate into increased emissions of pollutants. Similarly, regression results indicate that state road density (*ROADDEN*) positively influences changes in environmental regulation. These findings support the notion that highway expansions have increased vehicle miles traveled and this has also resulted in increased emission of pollutants due to changes in land use and neighborhood (Cassady, 2004). The coefficient for manufacturing establishment (*MFG*) has the expected positive sign and is significant at the 10 percent level. This implies that counties with a high number of manufacturing establishments are likely to have more pollution and thus attract more enforcement of environmental regulations.

To control for marginal exposures to pollution, we include the percent of the black population (*BLACK*) and the percent below the poverty rate (*POVRATE*) as explanatory variables for change in environmental regulations.[13] Surprisingly, regression results indicate that counties exhibiting a high percentage of the black population (*BLACK*) are associated with an increase in the stringency of environmental regulations. Similarly, the coefficient estimate for poverty rate (*POVRATE*) is positive and significant at the 1 percent level. These findings contradict the widely held view in the environmental justice literature that environmental regulations are more strictly enforced in predominantly white and affluent neighborhoods than in black and economically depressed neighborhoods (Melosi and Pratt, 2007). A cursory look at figure 2 shows that in 2004 none of Mississippi's counties had a non-attainment designation for the ozone standard. This is important in view of the fact that Mississippi contains the largest number of the Black population and has the highest unemployment rates in Appalachia. These findings corroborate Gray and Deily's (1995) finding that more enforcement actions are directed towards plants located in communities with high unemployment rates. By the same token, it can be inferred that more enforcement actions will be directed towards plants located in minority neighborhoods in order to increase political support.

6. **Conclusions and Implications**

This study contributes to the body of literature by extending the analysis of the economic growth-environmental regulation relationship beyond firms and industries directly affected by environmental regulations. A regional growth model that takes into account the simultaneous interactions among population, income, employment, and environmental regulations is estimated using 3SLS. Our findings in this study can be summarized in two main propositions. First, initial environmental regulation stringency is negatively related to regional growth factors of

[13] The environmental justice literature documents that the African American and Hispanic populations are disproportionately exposed to environmental damages than the white population. Furthermore, the literature provides anecdotal evidence that shows that majority of polluting industrial facilities is in low income areas—implying that people of lower socio-economic status will disproportionately suffer from environmental exposures (Sicotte, 2009).

population, employment, and per capita income. The initial conditions for environmental regulations intuitively suggest that firms in non-attainment counties invest in pollution abatement technologies in order to bring the air quality in compliance with federal standards. To this end, when firms initially invest in abatement capital, productivity (including labor demand) will go down, but this will be compensated by a gradual increase in environmental quality. Theoretically, this means that firms in the short-run will incur higher production costs due to investments in abatement technologies, and accordingly, the diversion of resources from production and investment activities will be inadvertently transmitted to other sectors of the economy—and thereby retard regional growth. This finding implicitly suggests that in the short-run there is a trade-off between environmental quality and economic growth.

Second, the empirical estimations show that change in environmental regulation is positively associated with regional growth factors of population, employment, and per capita income. Considering the fact that the time period for our analysis spans 15 years, we carefully interpret change in environmental regulations as the long-run effects. Within the endogenous growth theory framework, firms adopt improved technologies which gradually expand their production functions as well as improve environmental quality. Within this context, technological progress enables firms to lower the marginal cost of pollution control, and this allows firms to produce more with less pollution. Under this assumption, the efficient technology that firms invest in serves the dual role of improving productivity and enhancing environmental quality. In line with the amenities literature, improved environmental quality will positively influence firms' and households' (workers) location decisions and thus boost economic growth in terms of growth in population, income, and employment, respectively.

Like in previous studies, we find evidence that supports the hypothesis that changes in population, employment, and per capita income are interdependent. In addition, the empirical estimations show that socio-economic, political, and demographic characteristics influence the stringency of environmental regulations. The findings in this study reinforce the need to design and implement environmental regulations that stimulate economic growth and enhance environmental quality. Another policy implication is that besides imposing stringent environmental regulations on major polluting industries, attention needs to be paid to other socio-economic and demographic forces that contribute to emission of pollutants.

It would be interesting for future research to quantify the impacts of spillover-effects that emanate from the spatial heterogeneity in economic policies and environmental regulation implementation among and within Appalachian states. Also, empirical evidence that indicates that counties featuring high unemployment rates and high Black populations are associated with stringent environmental regulation stringency should be interpreted with caution. Could we be committing a type I error by inferring that poor neighborhoods are not excessively exposed to air pollution relative to other communities? Therefore, there is a need to further investigate the simultaneous relationship between rate of exposure to pollutants and environmental regulation stringency.

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Appendix 1: Description of Variables and Summary Statistics

Variables	Variable Description	Mean	Standard Deviation
	Endogenous Variables		
POPCH	Change in population (1992-2007) [A]	22862	6196.8
PCICH	Change in per capita Income (1992-2007) [A]	2152.3	10867
EMPCH	Change in total employment (1992-2007) [A]	13524	5453.5
ENREGCH	Change in attainment status (1992-2007): 0= attainment, ½ to 5= number of pollutants out-of-attainment [B]	0.6479	0.2829
Variables	**Variable Description**	**Mean**	**Standard Deviation**
	Initial Conditions		
EMP92	County employment in 1992 [A]	53959	25010
ENREG92	County attainment status in 1992 [B]	0.7334	0.329
PCI92	County per capita income in 1992 [A]	2530.2	13630
POP92	County population in 1992 [A]	89059	50945
	Exogenous Variables		
ACTIVE	Percentage of population between 18 years and 64 years[A]	30.582	62.61
AMEND	Natural amenities index[D]	1.1632	0.1326
CRIME	Serious crimes per 100,000 of population, 1992[A]	1560.8	2251.9
DEGREE	Percent of persons 25 yrs & above with college degree[A]	4.981	10.498
LGEXP	Per capita local government expenditure[A]	2344.7	3782.7
METRO	Metropolitan counties, dummy variable=1, 0 otherwise[D]	0.4410	0.26341
MFG	Number of manufacturing establishments in a county[C]	120.53	67.824
MFGEMP	Percent of civilian labor force employed in manufacturing[A]	11.367	26.236
MHVAL	County median housing value[A]	13528	47631
PCTAX	Local tax per capita, 1992[A]	160.88	285.31
POPDEN	Total population/land area[A]	133.03	101.27
Variable	**Variable Description**	**Mean**	**Standard Deviation**
POPDRIVE	Percentage of population above 17 years driving to work[A]	5.3388	73.827
POVRATE	Percent of families with income below poverty rate[A]	8.0139	19.019
PROPTAX	Per capita local property tax[A]	17.519	72.362
RETIRE	Percentage of population above 65 years[A]	2.6548	20.921
RISK	Percentage of population below 5 years plus above 65[A]	2.6548	20.921
ROADDEN	Miles of state roads per square mile[E]	0.1160	0.32637

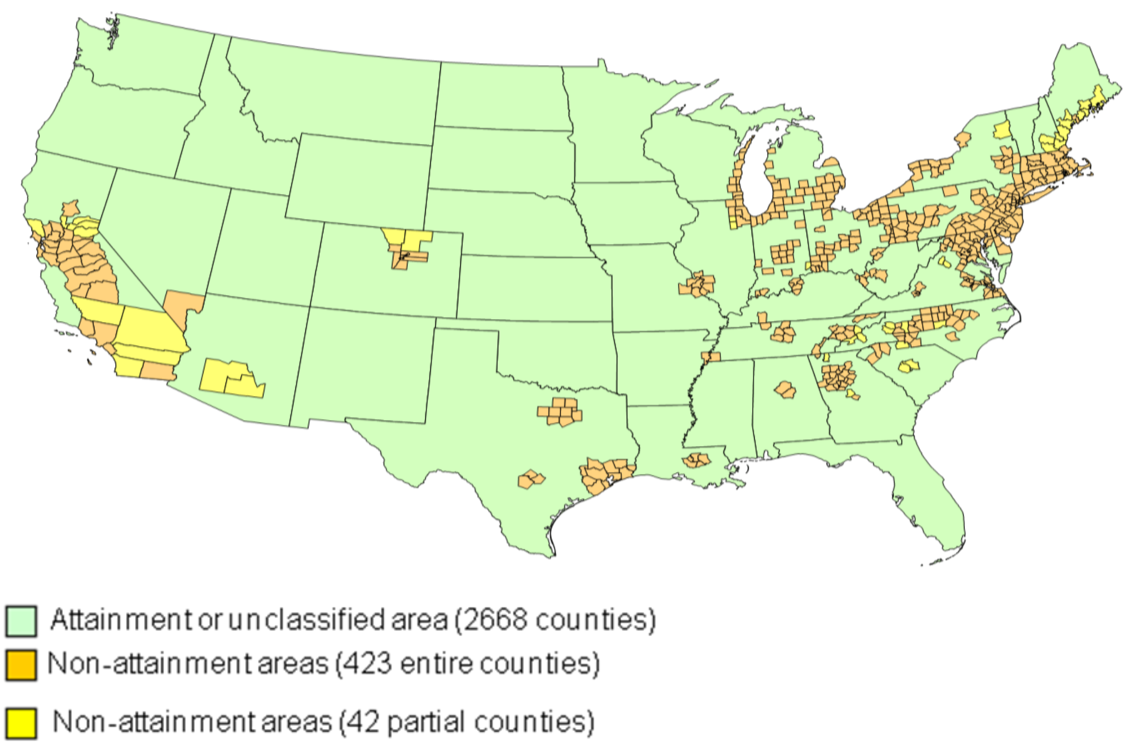
		1	
SIERRA	Dummy: 1 = Sierra chapters in a county, 0 otherwise[F]	0.4687 2	0.67561
UNEMP	Civilian labor force unemployment rate (percent) [A]	3.1947	9.3524
VOTE	Percentage of votes cast for Democratic President[A]	10.065	42.386

Sources**:** A**,** County & City Data Book**;** B**,** CFR, Title 40, Part 81, Subpart C and EPA Green book**;** C**, U.S.** Census Bureau (Dynamic Business Series); D, USDA/ERS-Creative class code; E**,** Natural Resource Analysis Center, West Virginia University; F, Sierra Club

Appendix 2: 3SLS Empirical Results with State Dummy Variables

Variable Name	ΔPopulation		ΔEmployment		ΔPer Capita Income		ΔEnvironmental Regulation	
	Coefficient	ρ Value	Coefficient	ρ Value	Coefficient	ρ Value	Coefficient	ρ Value
State Dummy Variables								
AL	11156	0.000	5375.81	0.023	376.487	0.3412	0.135	0.225
GA	30855	0.002	11924.1	0.032	340.426	0.3832	0.621	0.000
KY	3877.14	0.0001	−1102.33	0.004	−1350.710	0.0007	0.098	0.093
MD	10184	0.0317	3813.67	0.117	1037.711	0.2056	0.333	0.229
MS	4161.87	0.000	−1445.22	0.042	374.036	0.4701	0.213	0.945
NY	−101	0.936	−1947.62	0.0045	0.987	11.055	0.154	0.132
NC	11618.1	0.0000	2981.77	0.067	−485.7886	0.2363	0.066	0.151
OH	5316.03	0.000	1565.41	0.189	−1167.353	0.0053	0.448	0.000
PA	1684.52	0.515	4292.67	0.001	−1113.823	0.0126	0.596	0.000
SC	32857.6	0.010	14151.2	0.000	564.9907	0.4730	0.347	0.890
TN	11670.2	0.000	3898.18	0.02986	−260.281	0.538	0.235	0.003
VA	3199.48	0.000	−966.087	0.078	405.765	0.000	0.125	0.780
WV	2414.78	0.004	−427.364	0.445	−304.972	0.412	0.404	0.00
Constant	9013.233	0.001	7389.01	0.020	0.591	0.005	0.528	0.000
Adj. R^2	0.483	0.5580	0.4318	0.625				
Sample Size	410	410	410	410				

Figure 2: 2004 Attainment and Non-attainment Areas in the U.S. 8 Hour Ozone Standard



Source: EPA

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[i] The NAAQS are a set of standards that represent the maximum permissible ambient concentrations of the six pollutants. To promote public health and welfare, the CAA has assigned the primary responsibility for air pollution regulation to state and local governments. Thus, state and local governments administer the CAA by developing state implementation plans (SIP) which outline how states are going to comply with federal pollution standards. This means that U.S. states retain considerable flexibility in the implementation and enforcement of environmental regulations; this is reflected in the variation of regulatory intensity among states (Levison, 2000). Areas within a state that fail to meet the NAAQS for the six criteria pollutants established by the EPA are designated as non-attainment areas. A county's non-attainment status entails increased regulatory restrictions on polluting sources, and this, generally, results in increased pollution control compliance costs. In addition, the federal government can withhold federal funding for highway construction in non-attainment counties and impose a ban on the construction of new plants that would significantly add to emissions. Thus, the designation of a county as non-attainment may inadvertently result in loss of jobs and is likely to make a difference in whether or not a county will be able to retain and/or attract businesses.