Economic Growth and Environmental Regulations: A Simultaneous Equation Estimation

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This study employs a four-equation regional growth model to examine the simultaneous relationships among changes in population, employment, per capita income, and environmental regulations for the 420 counties in Appalachia. The results reveal that initial conditions for environmental regulations are negatively related to regional growth factors of change in population, per capita income, and total employment. From this, it is inferred 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 slowdown of regional growth. It also finds robust evidence that shows that changes in environmental regulations positively influence changes in population, total employment and per capita income. Thus, it is parsimoniously concluded that in the long run, environmental regulations are not detrimental to economic growth.

Introduction

The debate over the impact of environmental regulations on economic growth has a long history. Generally, the belief is that environmental regulations are detrimental to economic growth; therefore, their implementation has been controversial among economists and environmental policy makers. The debates over the past three decades have been over how to design environmental regulations that promote environmental quality without slowing down economic growth. The general consensus, however, is that many environmental problems such as climate change, water quality degradation, air quality problems, land degradation, habitat loss, and others are attributable to human activities.

To this end, concern over air quality problems in the US culminated with the passage of the Clean Air Act (CAA) in 1970, which was amended in 1977 and 1990. The 1970 CAA 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 NAAQS are a set of standards that represent the maximum permissible ambient concentration of the six pollutants. To promote public

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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 the US states retain considerable flexibility in the implementation and enforcement of environmental regulations; this is reflected in the variation of regulatory intensity among states (Levinson, 2001). 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.[1]

Earlier studies examining the economic impacts of environmental regulation produce mixed results. Several researchers, including Gray and Shadbegian (1993), List and Co (1999), and Fredriksson and Millimet (2002a), find evidence that show that environmental regulations negatively affect economic growth. On the other hand, Bartik (1985), McConnell and Schwab (1990), and Levinson (1996) find little or insignificant evidence in this regard. Moreover, the focus of these earlier studies has been exclusively on affected industries in the manufacturing sector (Duffy, 1992; Jaffe and Palmer, 1996; and 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 and 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 (1984, p. 39) points out that the "effects of 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, employment change, and other socioeconomic factors. This

[1] 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. Theoretically, the principal rationale for classifying counties as non-attainment is due to market failure—that is when the air quality of a county exceeds the federal ambient air quality standards. Thus, the designation of a county as non-attainment may inadvertently result in loss of economic development opportunities, and is likely to make a difference in whether or not a county will be able to retain and/or attract businesses. From the neoclassical economic point of view, variations in environmental regulation implementation among and within states will have significant impact on the mobility of capital and other resources across local jurisdictions, and this may affect economic growth.

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 by 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-wise 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 NAAQS as a proxy for environmental regulations and allow the cross-sectional variation of the attainment variable.[2]

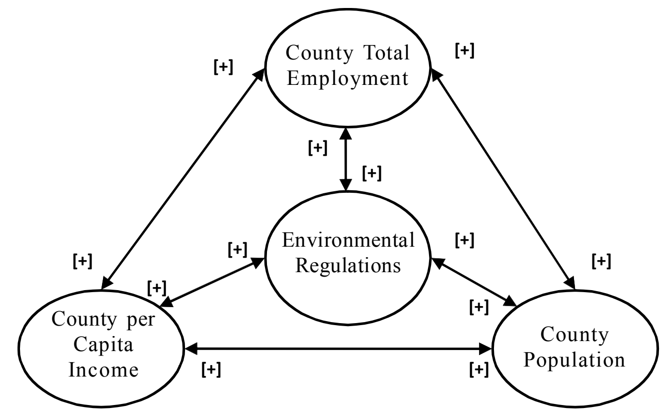
The motivations for specifying a four-equation simultaneous model is straightforward:

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. Intuitively, this implies that higher levels of per capita income raise the public's demand for environmental regulation, which translates into improved environmental quality;
2. Cognizant of the fact that the environment provides the basic inputs for production and consumption for households and firms, an increase in population and economic activity may inevitably intensify the problem of environmental degradation. Because of the amenity and productive values associated with the environment, this may result in society's preference for a clean environment. From the foregoing, it is reasonable to conclude that changes in population and total employment will increase environmental awareness; and
3. Relatedly, enforcement of environmental regulations will result in improved environmental quality and make a location more attractive for households and

[2] While Pollution Abatement Costs and Expenditures (PACE) data have been widely used as a measure of environmental regulation stringency at the state level, a survey of the empirical literature reveals a lack of consensus on the appropriate measure for environmental regulation stringency at the county level. Studies by McConnell and Schwab (1990), Henderson (1997), Becker and Henderson (2000), List (2001), Greenstone (2002), List *et al*. (2003 and 2004); and Becker (2005) use county attainment/non-attainment status of the CAA's NAAQS as a proxy for environmental stringency. These studies find some compelling evidences which show that county attainment status has an effect on manufacturing employment, firm location, and investment decisions. It should be noted that the measure of environmental regulation used in these studies is a dummy variable and the empirical model is in form of a single equation. However, in this study, we employ a measure of environmental regulation stringency that is continuous and we specify simultaneous equations that capture the interdependencies among the variables.

businesses. In effect, this will bolster population, income, and employment growth. These stylized relationships are shown in Figure 1. It shows that an increase in population growth has a positive effect on a county's per capita income, reflecting an increase in labor supply and its effect on output. According to the figure, environmental regulations stimulate population growth and economic activity. This is possible because a clean environment will attract new businesses and new migrants.

Figure 1: Simultaneous Interactions Between Environmental Regulations and Economic Growth



Overall, this study extends the knowledge by accounting for the feedback relationships, using a four-equation simultaneous regional growth model that captures the interdependencies among population, employment, per capita income, and environmental regulations. There is currently no study that has considered these interdependencies. 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: it provides an analytical framework for modeling the relationship between environmental regulations and growth. Subsequently, it presents the data sources and types, followed by the results. Finally, the conclusion is offered.

Analytical Framework

Within the context of the environmental Kuznets curve literature, factors such as population density, income, industrial composition, and other socioeconomic indicators have been found to 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 (due to differences in environmental regulation stringency), thereby resulting in different levels of population, employment, and income growth rates across regions.

The regional growth impacts of environmental regulations can be understood using regional growth models which emphasize the interdependencies of household residential and firm location choices. The premise of these regional growth models is that utility maximizing consumers migrate in search of utility derived from the consumption of market and non-market goods, while profit maximizing firms, on the other hand, become mobile looking for regions that have lower production costs and higher market demand (Carlino and Mills, 1987; and Deller *et al.,* 2001).[3] On the assumption that the long-run benefits of environmental regulations are improved industry productivity and enhancement of a jurisdiction's environmental quality, we infer that equilibrium levels of employment, population, and per capita income will be affected by environmental regulations.

For consideration of the above economic impacts of environmental regulations, we extend Deller *et al.*'s (2001) model by specifying a four-equation simultaneous 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 upon each other, but will also interact with other exogenous factors, including the lagged values of the endogenous variables.

The four-equation simultaneous model representing the interactions among population (*POP*), employment (*EMP*), income (*Y*), and environmental regulations (*ER*) is specified as follows:

$$POP^* = \alpha_{0POP} + \beta_{1POP}EMP^* + \beta_{2POP}Y^* + \beta_{3POP}ER^* + \sum \delta_{IPOP}\Omega^{POP} \quad ...(1)$$

$$EMP^* = \alpha_{0EMP} + \beta_{1EMP}POP^* + \beta_{2EMP}Y^* + \beta_{3EMP}ER^* + \sum \delta_{IE}\Omega^{EMP} \quad ...(2)$$

$$Y^* = \alpha_{0Y} + \beta_{1Y}POP^* + \beta_{2Y}EMP^* + \beta_{3Y}ER^* + \sum \delta_{IY}\Omega^{Y} \quad ...(3)$$

$$ER^* = \alpha_{0ER} + \beta_{1ER}POP^* + \beta_{2ER}Y^* + \beta_{3ER}EMP^* + \sum \delta_{IER}\Omega^{ER} \quad ...(4)$$

where POP^*, EMP^*, Y^* and ER^* represent equilibrium levels of population, employment, per capita income and environmental regulations, respectively in the i^{th} county; Ω^{POP}, Ω^{EMP}, Ω^{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 respectively. Equations (1) to (4) state that equilibrium levels of population, employment, income, and environmental

[3] This phenomenon is akin to Tiebout's (1956) sorting hypothesis, which states that through the choice process of individuals, jurisdictions and residents determine an equilibrium provision of local public goods in accordance with the tastes of residents.

regulations depend on actual population, employment, income, and environmental regulations, as well as other exogenous variables in Ωs.

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

$$POP_t = POP_{t-1} + \lambda_p\left(POP^* - POP_{t-1}\right) \quad ...(5)$$

$$EMP_t = EMP_{t-1} + \lambda_E\left(EMP^* - EMP_{t-1}\right) \quad ...(6)$$

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

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

The subscript ($t-1$) refers to the initial conditions of the endogenous variables, which in this case are the 1992 values, while λ_p, λ_E, λ_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 0 and 1. Equations (5) to (8) show that current employment, population, income, and environmental regulations are dependent on their initial conditions and on the change from their equilibrium values and on their lagged values.

After rearrangement and substitution, the proposed empirical model is specified as follows:

$$\Delta POP = \alpha_{0P} + \beta_{1P}POP_{1992} + \beta_{2P}Y_{1992} + \beta_{3P}ER_{1992} + \beta_{4P}\Delta EMP + \beta_{5P}\Delta Y + \beta_{6P}\Delta ER + \beta_{7P}DUM + \sum \delta_{IP}\Omega^P + \mu_1 \quad ...(9)$$

$$\Delta EMP = \alpha_{0E} + \beta_{1E}EMP_{1992} + \beta_{2E}POP_{1992} + \beta_{3E}ER_{1992} + \beta_{4E}\Delta POP + \beta_{5E}\Delta Y + \beta_{6E}\Delta ER + \beta_{7E}DUM + \sum \delta_{IE}\Omega^E + \mu_2 \quad ...(10)$$

$$\Delta Y = \alpha_{0Y} + \beta_{1Y}EMP_{1992} + \beta_{2Y}Y_{1992} + \beta_{3Y}POP_{1992} + \beta_{4Y}ER_{1992} + \beta_{5Y}\Delta POP + \beta_{6Y}\Delta EMP + \beta_{7Y}\Delta ER + \beta_{8Y}DUM + \sum \delta_{IY}\Omega^Y + \mu_3 \quad ...(11)$$

$$\Delta ER = \alpha_{0ER} + \beta_{1ER}Y_{1992} + \beta_{2ER}POP_{1992} + \beta_{3ER}ER_{1992} + \beta_{4ER}\Delta POP + \beta_{5ER}\Delta Y + \beta_{6ER}\Delta ER + \beta_{7ER}DUM + \sum \delta_{IER}\Omega^{ER} + \mu_4 \quad ...(12)$$

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.[4] 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 level is embedded in the coefficients α, β and δ. Therefore, Equations (9) to (12) estimate the short-term adjustments of population, employment, income, and environmental regulations to their long-term equilibrium levels (POP^*, EMP^*, Y^* and ER^*).

Data and Variables

The study area is confined to the 420 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 period from 1992 to 2010. The dependent variables used in the models are measured as absolute changes in population, employment, income, and environmental regulations (see Table 1). County-level data for population, employment, and income are obtained from the Bureau of Economic Analysis, Regional Economic Information System (REIS) and County and City Data Book (C&CDB). 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.

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 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, while 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 1/2.

A number of explanatory variables are included to explain changes in population, employment, income, and environmental regulations (see Table 1). Specification of variables in the population equation follows economic theory and existing literature. Variables in the employment equation have been chosen for their ability to reflect long-run supply and demand conditions in the labor market in a given county, while variables in the income equation are chosen based on their hypothesized relationship to productivity gains. Similarly, exogenous variables in the environmental regulation are chosen based on their ability to reflect the supply/demand for environmental regulations.

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

Table 1: Description of Variables and Summary Statistics			
Variables	**Variable Description**	**Mean**	**SD**
Endogenous Variables			
POPCH	Change in population (1992-2007)[A]	22862	6196.8
PCICH	Change in per capita income (1992-2010)[A]	2152.3	10867
EMPCH	Change in total employment (1992-2010)[A]	13524	5453.5
ENREGCH	Change in attainment status (1992-2010): 0 = Attainment, ½ to 5 = Number of pollutants out-of-attainment [B]	0.6479	0.2829
Initial Conditions			
*EMP*92	County employment in 1992 [A]	53959	25010
*ENREG*92	County attainment status in 1992 [B]	0.7334	0.329
*PCI*92	County per capita income in 1992 [A]	2530.2	13630
*POP*92	County population in 1992 [A]	89059	50945
Exogenous Variables			
ACTIVE	Percentage of population between 18 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 years and 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

Table 1 (Cont.)

Variables	Variable Description	Mean	SD
Exogenous Variables			
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
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 years[A]	2.6548	20.921
ROADDEN	Miles of state roads per square mile[E]	0.11601	0.32637
SIERRA	Dummy = 1: Sierra chapters in a county, 0: Otherwise[F]	0.46872	0.67561
UNEMP	Civilian labor force unemployment rate (%)[A]	3.1947	9.3524
VOTE	Percentage of votes cast for Democratic President[A]	10.065	42.386

Source: A – County and City Data Book; B – CFR, Title 40, Part 81, Subpart C and EPA Green Book; C – US Census Bureau (Dynamic Business Series); D – USDA/ERS-Creative Class Code; E – Natural Resource Analysis Center, West Virginia University; F – Sierra Club

Empirical Results and Analysis

Table 2 presents the estimated coefficients of the equations based on three-stage least squares estimation. The regression results reported exclude state dummy variables.[5] Based on the adjusted R^2 statistics, the estimated models explain 48%, 55%, 43%, and 62% of variations in changes in population, employment, per capita income, and environmental regulations, respectively.

[5] Complete results with state dummy variables are presented in the Appendix. 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 2: Three-Stage Least Squares Results for Appalachian Region								
Variable Name	ΔPopulation		ΔEmployment		ΔPer Capita Income		ΔEnvironmental Regulation	
	Co-efficient	*p*-Value	Co-efficient	*p*-Value	Co-efficient	*p*-Value	Co-efficient	*p*-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	0.233	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
RISK	–	–	–	–	–	–	0.008	0.001

Table 2 (Cont.)

Variable Name	ΔPopulation		ΔEmployment		ΔPer Capita Income		ΔEnvironmental Regulation	
	Co-efficient	p-Value	Co-efficient	p-Value	Co-efficient	p-Value	Co-efficient	p-Value
RETIRE	–	–	–	–	–39.729	0.000	–	–
BLACK	–	–	–	–	–128.570	0.0807	0.001	0.000
Locational Variables								
METRO	8,401.985	0.000	–2,611.31	0.065	–	–	–0.251	0.000
ROADDEN	2,329.112	0.570	606.332	0.785	–	–	0.124	0.002
CRIME			0.017	0.834	–	–	–	–
Environmental Quality Variables								
AMEND	1,760.273	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
POPDEN	–	–	–	–	–	–	0.0026	0.001
Constant	9,013.233	0.001	7,389.01	0.020	0.591	0.005	0.528	0.000
Adj. R^2	0.483	0.5580	0.4318	0.625				
Sample Size	420	420	420	420				

The structural equations were assessed as to whether they were identified by examining the rank and order conditions. Table 3 shows that the structural equations are over-identified in terms of the order condition, while the rank condition is satisfied.

Table 3: Identification of Structural Equations

	ΔPopulation	ΔEmployment	ΔPer Capita Income	ΔEnvironmental Regulation
(K_j)	11	11	11	8
(M_j)	3	3	3	3
Rank (A_j^*)	3	3	3	3

Change in Population Equation

Consistent with expectations, the 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 (*POP*92) has a negative sign and is significant at 1% level (Table 2). This finding confirms the convergence hypothesis, which suggests that Appalachian counties which had initial high levels of population tend to experience a lower growth rate than counties which had low levels of population in the initial period. Another important initial condition that deserves attention is that of environmental regulations. Except for environmental regulations, all the initial conditions have a strong effect on population growth and have the expected signs.[6]

Table 2 shows that the coefficient estimate for change in environmental regulations (*ENREGCH*) has a positive impact on change in population and is statistically significant at 10% level. One possible explanation may be that stringent environmental regulations result in improved environmental quality and thus make local areas more attractive for businesses and households. From the neoclassical standpoint, this implies that utility maximizing individuals will migrate to areas with better environmental quality.

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 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 5% level).

Generally, high unemployment rates indicate economic distress and a dearth of employment opportunities, and this is reflected by the negative coefficient on unemployment rate. The coefficient for metropolitan county (*METRO*) is positive and statistically significant at 1% 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. The regression analysis also reveals a significant positive relationship between amenities index (*AMEND*) and population growth. These findings are consistent with those of some previous studies (e.g., Deller *et al.*, 2001).

Change in Employment Equation

The estimated results for change in employment equation are shown in Column 3 of Table 2. The initial condition for employment (*EMP*92) 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 experienced faster growth in employment than counties that had high initial levels of employment. These results are consistent with those

[6] Under the assumption that before a firm adopts pollution abatement technologies, a county's environmental quality is poor, in this manner, a jurisdiction's poor air quality will make the area unattractive to workers (discourage population growth) and thereby constrain labor supply.

of Black *et al.* (2007) about the convergence in employment rates in the Appalachian region. Black *et al.* 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 government employment.

The estimated coefficient on initial conditions for population (*POP92*) is statistically significant and positive, thus supporting the hypothesis that people-follow-jobs, meaning that increase in population entails a larger supply of labor. Another initial condition variable of great interest is environmental regulations. The coefficient on the initial condition for environmental regulations (*ENREG*92) has 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 SIPs at the end of 1992. Therefore, between 1990 and 1992, polluting firms faced stringent standards with regard to pollution control. The stringent regulations imposed may have negatively affected employment growth in the initial years of implementation due to the fact that polluting firms had to install expensive pollution abatement control equipment. The effect of this may inadvertently be transmitted to other sectors of the economy, hence resulting in the overall slowdown of total employment growth.

On the other hand, the coefficient on the change in environmental regulations (*ENREGCH*) is positive and statistically significant at 1% level.[7] 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 (Porter and Linde, 1995). The efficient technology that 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. These findings are also consistent with those of previous studies (Ringquist, 1993; Goetz *et al*., 1996; Mohr, 2002; and Mohr and Saha, 2008) in revealing that the short-run effect of environmental regulation is 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 1% 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 1% level and is positively related to employment growth. This means that Appalachian counties with high income experienced increased growth in employment. This could be attributed to the economy-wide diversification that has taken place in the Appalachia.

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

[7] 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 stimulating growth in employment. Mohr's (2002) general equilibrium model shows that environmental regulations can simultaneously increase productivity and reduce pollution.

for environmental regulation (*ENREG*92) mirrors the results obtained in the employment and population equations (negative and significant at 1% 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 result in reduced growth in per capita income.

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, in higher per capita income. The variable *EMPCH* has the expected positive sign and is significant at 5% 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 1% 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; and Goetz *et al*., 1996). To this end, we parsimoniously interpret the effect of initial condition of environmental regulations as the short-run effect due to the fact that in the initial period, firms in non-attainment regions invest in pollution abatement technologies. By contrast, we interpret the effect of change in environmental regulations as the long-run effect.

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 5% level. The Democratic presidential candidate (*VOTE*) variable is included to capture the 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 of *VOTE.* Similarly, locational 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 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 expected positive sign, but is insignificant. By contrast, an increase in the percentage of population 65 years old and above (*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 incomes are unlikely to experience income growth. Another demographic variable related to income growth is the percentage of Black population (*BLACK*). The coefficient for *BLACK* is negative and significant at 10% 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.[8] 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.

Change in Environmental Regulations Equation

Estimated results for the environmental regulations equation are presented in Column 5 of Table 2. The estimated coefficient for 1992 environmental regulations (*ENREG*92) is positive and statistically significant at 1% 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 (*POP*92) is positively related to change in environmental regulation and is significant at 1% level. This finding illustrates that air pollution varies with population and therefore, an increase in population will positively influence environmental regulations stringency. However, the magnitude of the population coefficient is very small. The coefficient for the 1992 per capita income (*PCI*92) 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, change in per capita income (*PCICH*) has a positive effect on environmental regulation change (see 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 positive and statistically significant at 10%, 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 5% level. These results provide evidence that environmental pressure groups are pro-environmental and will exert pressure on regulatory agencies for enforcement of stringent environmental regulations.

[8] Young *et al.* (2007) examine the relationship between race and economic growth using county-level data on per capita income and 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.

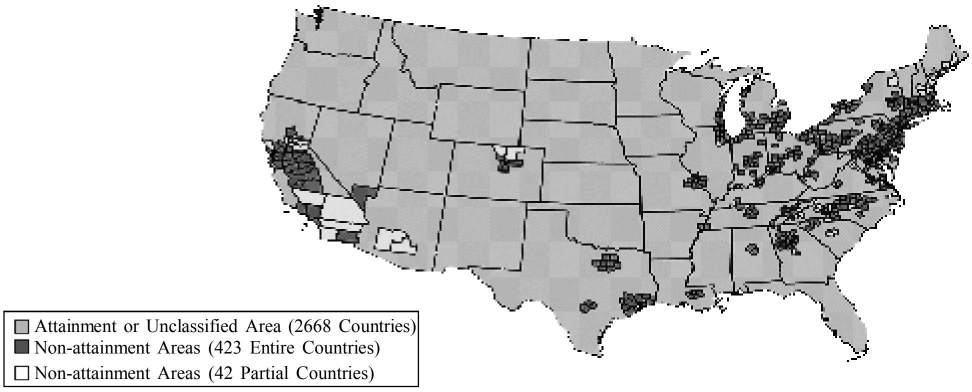
Previous studies also show that the stringency of the US environmental regulations is influenced by the political party that controls the executive branch and legislature (Hays, 1993; Regens *et al*., 1997; and Lynch, 2001). Accordingly, the percent of votes cast for the Democratic presidential candidate (*VOTE*) appears to have a positive influence on environmental regulations outcomes. This finding is in accordance with that of Kahn and Matsusaka's (1997) 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 level of college graduates are more prone to support stringent environmental regulations and are likely to lobby effectively against pollution (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 10% 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 percentage of the black population (*BLACK*) and the percentage below the poverty rate (*POVRATE*) as explanatory variables for change in environmental regulations.[9] 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 1% 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

[9] 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 a majority of polluting industrial facilities are in low income areas, implying that people of lower socioeconomic status will disproportionately suffer from environmental exposures (Sicotte, 2009).

Figure 2: Attainment and Non-Attainment Areas in the US 8 h Ozone Standard, 2004



Source: *EPA*

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.

Conclusion and Implications

This study extends the analysis of 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 three-stage least squares model. The findings are summarized as follows: first, initial environmental regulations negatively influence regional growth factors of population, employment, and per capita income. The initial conditions for environmental regulations suggest that firms in non-attainment counties invest in pollution abatement technologies in order to bring the air quality in compliance with federal standards. 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. 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 of our analysis spans 15 years, we parsimoniously interpret effect of change in environmental regulations as the long-run effect. Within the endogenous growth theory framework, firms adopt efficient technologies which gradually expand their production functions as well as improve their environmental quality. 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 positively influences firms' and households' location decisions, thereby boosting economic growth in terms of growth in population, income and employment.

Finally, 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 socioeconomic, 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 socioeconomic and demographic forces that contribute to emission of pollutants. Although the state dummy variable indicates that state differences influence growth and environmental outcomes, future research should quantify the spillovers that emanate from the spatial heterogeneity in economic policies and environmental regulation implementation among and within states. ❖

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Appendix

3SLS Empirical Results with State Dummy Variables								
Variable	**ΔPopulation**		**ΔEmployment**		**ΔPer Capita Income**		**ΔEnvironmental Regulation**	
	Co-efficient	***p*-Value**	**Co-efficient**	***p*-Value**	**Co-efficient**	***p*-Value**	**Co-efficient**	***p*-Value**
State Dummy Variables								
Alabama	11,156	0.000	5,375.81	0.023	376.487	0.3412	0.135	0.225
Georgia	30,855	0.002	1,1924.1	0.032	340.426	0.3832	0.621	0.000
Kentucky	3,877.14	0.0001	–1102.33	0.004	–1,350.710	0.0007	0.098	0.093
Maryland	10,184	0.0317	3,813.67	0.117	1,037.711	0.2056	0.333	0.229
Mississippi	4,161.87	0.000	–1,445.22	0.042	374.036	0.4701	0.213	0.945
New York	–101	0.936	–1,947.62	0.0045	0.987	11.055	0.154	0.132
North Carolina	11,618.1	0.0000	2,981.77	0.067	–485.7886	0.2363	0.066	0.151
Ohio	5,316.03	0.000	1,565.41	0.189	–1,167.353	0.0053	0.448	0.000
Pennsylvania	1,684.52	0.515	4,292.67	0.001	–1,113.823	0.0126	0.596	0.000
South Carolina	32,857.6	0.010	14,151.2	0.000	564.9907	0.4730	0.347	0.890
Tennessee	11,670.2	0.000	3,898.18	0.02986	–260.281	0.538	0.235	0.003
Virginia	3,199.48	0.000	–966.087	0.078	405.765	0.000	0.125	0.780
West Virginia	2,414.78	0.004	–427.364	0.445	–304.972	0.412	0.404	0.00
Constant	9,013.233	0.001	7,389.01	0.020	0.591	0.005	0.528	0.000
Adj. R^2	0.483	0.5580	0.4318	0.625				
Sample Size	420	420	420	420				

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