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Source: *Southern Economic Journal*, Vol. 66, No. 1 (Jul., 1999), pp. 144-155

Published by: Southern Economic Association

Stable URL: <http://www.jstor.org/stable/1060840>

Accessed: 30-08-2016 18:12 UTC

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Have Air Pollutant Emissions Converged Among U.S. Regions? Evidence from Unit Root Tests

John A. List*

Previous studies of income distribution have found evidence indicating that incomes across U.S. regions have converged, supporting the prediction of the neoclassical growth model. A potential shortcoming in these studies is that only one measure of well-being is considered—a measure of wealth linked to incomes or production. This paper examines whether income convergence was accompanied by air pollutant emission convergence. Results from unit root tests provide some evidence that indicators of environmental quality have converged across U.S. regions during the 1929–1994 period.

1. Introduction

An important implication of Solow's (1956) neoclassical growth model is that a region's growth rate in per capita income is inversely related to its initial per capita income, suggesting that poorer regions should "catch up" to relatively richer regions over time. This proposed phenomenon has received considerable attention since the mid-1950s, inducing many fruitful lines of research. For example, motivated by findings of persistent disparities of intercountry incomes, Romer (1986) and Lucas (1988) initiated a new branch of endogenous growth literature that has led to empirical tests using cross-section and time-series techniques to test if economies have exhibited cross-sectional and/or stochastic (time-series) convergence.

Recent studies of cross-sectional and stochastic convergence have found evidence supporting the neoclassical theory of income convergence. For instance, using U.S. regional per capita income data from 1929–1990, Carlino and Mills (1993) find that as many as three of the eight Bureau of Economic Analysis (BEA) regions have converged. In a related study, Loewy and Papell (1996) use an endogenously determined break point model to show that per capita incomes in five BEA regions have converged during the 1929–1990 period. Finally, Barro and Sala-i-Martin (1992) find that per capita income and gross state product have converged across states from 1880 to 1988.¹

Although the available evidence indicates that the disparity between regional per capita incomes has lessened across the U.S., a potential shortcoming in these studies is that only one measure of well-being is considered—a measure of wealth linked to incomes or production. Inherent in many theoretical models (e.g., Wilson 1987) is the possibility that regions may

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Thanks to Kevin Grier and to an anonymous referee for very helpful comments. Michael Margolis, Mark Strazicich, and Junsoo Lee provided useful suggestions on an earlier version of this paper. The usual caveats apply.

Received September 1997; accepted February 1999.

¹ See Gottschalk and Smeeding (1997) for a good discussion of previous research on income inequality.

converge in incomes when specialization occurs—poorer regions specialize in the production of pollution-intensive goods and experience large increases in per capita income, whereas richer regions specialize in the production of clean goods and subsequently have a lower growth rate in per capita income. In this scenario, it is quite possible that regions are converging in monetary wealth but diverging in “green incomes,” or income levels adjusted for environmental quality. If this phenomenon has occurred, then previous findings of income convergence may not be as appealing as first implied.

This paper uses data on two indicators of environmental quality—emissions of sulfur dioxides and nitrogen oxides—to examine if environmental quality has converged across the U.S. during the 1929–1994 period. The main empirical results provide initial evidence that regional per capita emissions have stochastically converged. These results suggest that poorer regions have not had to trade off environmental quality for their relative gains in income levels. A possible interpretation of this result, explored more fully below, regards the optimal institutional arrangements for pollution control. Although a key underlying premise of U.S. environmental policy in the last three decades has been that if states were allowed to do so, they would compete with each other for industry by adopting weaker environmental regulations,² these results suggest that empowering the states to carry out environmental programs will not lead to some sort of bleak world where rivers catch on fire and air becomes routinely visible.

The remainder of this paper proceeds as follows: Section 2 provides a brief review of the income convergence literature, describes the data, and outlines the conditional convergence hypothesis. Section 3 presents the empirical methods and regression results and discusses policy implications. Section 4 provides concluding comments.

2. Previous Research, the Data, and the Hypothesis

Previous Research

Given the implications of the neoclassical growth model, research on income convergence has been the subject of continuing debate. Empirical methods to analyze income convergence include both cross-sectional and time-series techniques. Cross-sectional research includes tests for β -convergence, attributable to Baumol (1986), and σ -convergence, attributable to Barro (1991). Baumol (1986) and Barro (1991) find evidence in favor of β -convergence using cross-country data. Barro and Sala-i-Martin (1991) present evidence that supports β - and σ -convergence across 73 regions of Western Europe, whereas Barro and Sala-i-Martin (1992) find that U.S. states have β - and σ -converged. Furthermore, using rank dominance techniques, Bishop, Formby, and Thistle (1992) present evidence that suggests that U.S. South and non-South incomes have converged from 1969 to 1979. In sum, cross-sectional studies support the income convergence hypothesis.

Although the cross-sectional notion of convergence is appealing, Quah (1990) and others have argued that the more relevant issue is how persistent the effects of random shocks are on regional per capita incomes. This premise has led researchers to formulate a time-series (stochastic) notion of convergence. In these models, convergence is evident if per capita income

² Justification for these worries can be found in theoretical studies of environmental quality provision (see, e.g., Oates and Schwab 1988; Markusen, Morey, and Olewiler 1995) and of public goods provision when financed by taxing geographically mobile factors (Wildasin 1989).

disparities between economies follow a zero mean stationary process. An alternative definition of stochastic convergence, attributable to Carlino and Mills (1993, 1996), is that the log of relative (to that of the overall economy) per capita income is stationary.

Unlike the findings of cross-sectional studies, results from the time-series literature are mixed. Quah (1990) finds little evidence of cross-country stochastic convergence among capitalist economies, whereas Campbell and Mankiw (1989) and Bernard and Durlauf (1995) present similar results for OECD economies. In addition, Brown, Coulson, and Engle (1990) find limited evidence of stochastic convergence across U.S. states. On the other hand, Carlino and Mills (1993) use regional data from 1929–1990 to show that as many as three of the eight BEA regions have stochastically converged. In a related study, Loewy and Papell (1996) use an endogenously determined break point model to show that as many as five of the eight BEA regions have converged from 1929–1990. These latter time-series studies complement the aforementioned cross-section work and serve to provide further evidence that incomes have converged across U.S. regions.

Data Description

To test whether air pollutant emissions have converged across Environmental Protection Agency (EPA) Regions, I use data on two indicators of environmental quality—emissions of sulfur dioxides and nitrogen oxides.³ These data are for the period 1929–1994 and come from the EPA publication *National Air Pollutant Emission Trends (NAPET), 1900–1994*. Over this period, EPA's methodologies for estimating emissions fall into two major categories, corresponding to the periods 1929–1984 and 1985–1994. The EPA calculated emissions from 1929–1984 using a “top-down” approach in which national information was used to create an emission estimate based on economic activity, material flows, consumption of fuel, and, in the case of combustion sources, the fuel type. The EPA then allocated these national estimates to regions based on regional production activities. From 1985 to 1994, the EPA estimated emissions using a “bottom-up” methodology in which emissions were derived at the plant or county level and aggregated to the regional level. Although one potential problem with analyzing the results of the EPA's estimation procedures concerns the uniting of two potentially heterogeneous data sets, empirical methods described below control for this potential aggregation problem.

Another possible concern relates to the pollution regulatory regimes during the sample period—with the writing of the Clean Air Act Amendments in 1970, the U.S. federal government effectively reversed more than 90 years of state and local authority of polluters. The centralization of standard-setting provided uniformity to environmental policies across space as maximum pollution concentration levels and minimum installation of Best Available Control Technology laws were included in early environmental legislation. Since environmental enforcement has long been left to the states (Portney 1990), however, uniform standards at the federal level do not imply that emission levels have converged.⁴ Nevertheless, empirical methods account for this potential problem by allowing a trend break in the time path of regional emission levels.

To provide a feel for the nature of the time-series paths, I plot the regional trends of the log of relative per capita emissions of oxides of nitrogen (NO_x) and sulfur dioxides (SO_2) from

³ The Appendix lists states as categorized by Environmental Protection Region. Regional population estimates are from the Bureau of Economic Analysis, U.S. Department of Commerce, 1929–1994.

⁴ See List and Gerking (1996) for a more complete treatment of this argument.

1929–1994 in Figure 1. Trends for the NO_x series indicate that, from 1929 to 1994, EPA Regions 6 and 8 typically experienced per capita emissions above the national average, whereas Regions 1 and 2 had per capita emissions below the national average. Figure 1 also reveals that EPA Regions 5 and 8 had above average SO₂ emission levels, whereas Regions 1, 2, and 10 had below average per capita emission levels for the majority of the sampling period. Many factors may play a role in determining a region's relative trend in emissions. For example, EPA Region 8, which had above average emission levels for both pollutant types during the 1929–1994 period, is comprised of sparsely populated low-income states. On the other hand, EPA Region 2, which contains two high-income states, New York and New Jersey, had emission levels below the national average for both pollutant types. One possible interpretation of these trends is that in regions with higher incomes, industry faces greater public pressure to make pollution abatement expenditures, which yields lower per capita emission levels. This pressure could operate through several channels, including the activities of environmental public interest groups or the regulatory action taken by state departments of environmental quality.

Conditional Convergence Hypothesis

Economic theory offers many explanations for the spatial heterogeneity of air pollutants observed in Figure 1. Differences in willingness-to-pay (WTP) for environmental amenities is arguably the most popular because it is embodied in the theory of profit maximization: assuming spatial differences in WTP, rational polluting firms will locate where the expected losses from polluting will be at a minimum, *ceteris paribus*. Economic factors should therefore influence environmental outcomes because compensation demands by relatively richer constituents will most likely be larger than demands by the economically disadvantaged. Consequently, micro-economic theory does not rule out the premise that income convergence induces a regional equilibrium where emissions vary by a constant differential.⁵

Mankiw, Romer, and Weil (1992) term this type of convergence “conditional” because it is characterized by regions converging to a constant differential. When empirically testing for emission convergence below, I use Mankiw, Romer, and Weil's 1992 nomenclature and follow Carlino and Mills' 1996 proposition of convergence: (i) regions having per capita emissions initially above their compensating differential should exhibit slower growth in emissions than those regions having per capita emissions below their compensating differential (cross-sectional convergence), and (ii) shocks to relative regional per capita emissions should be temporary (stochastic convergence).

3. Empirical Methods and Results

Because previous studies of income convergence approach the problem using both cross-sectional and time-series methods, I present results from both techniques. I should also note that the concept of emission convergence is inherently an out-of-equilibrium phenomenon. This assumption makes sense, as the convergence hypothesis presumes that EPA Regions begin in disequilibrium and achieve equilibrium through time.

⁵ Of course this is a simplification; polluting firms most definitely take into account other important factors in the production and political processes as well as the natural capacity of their local environments.

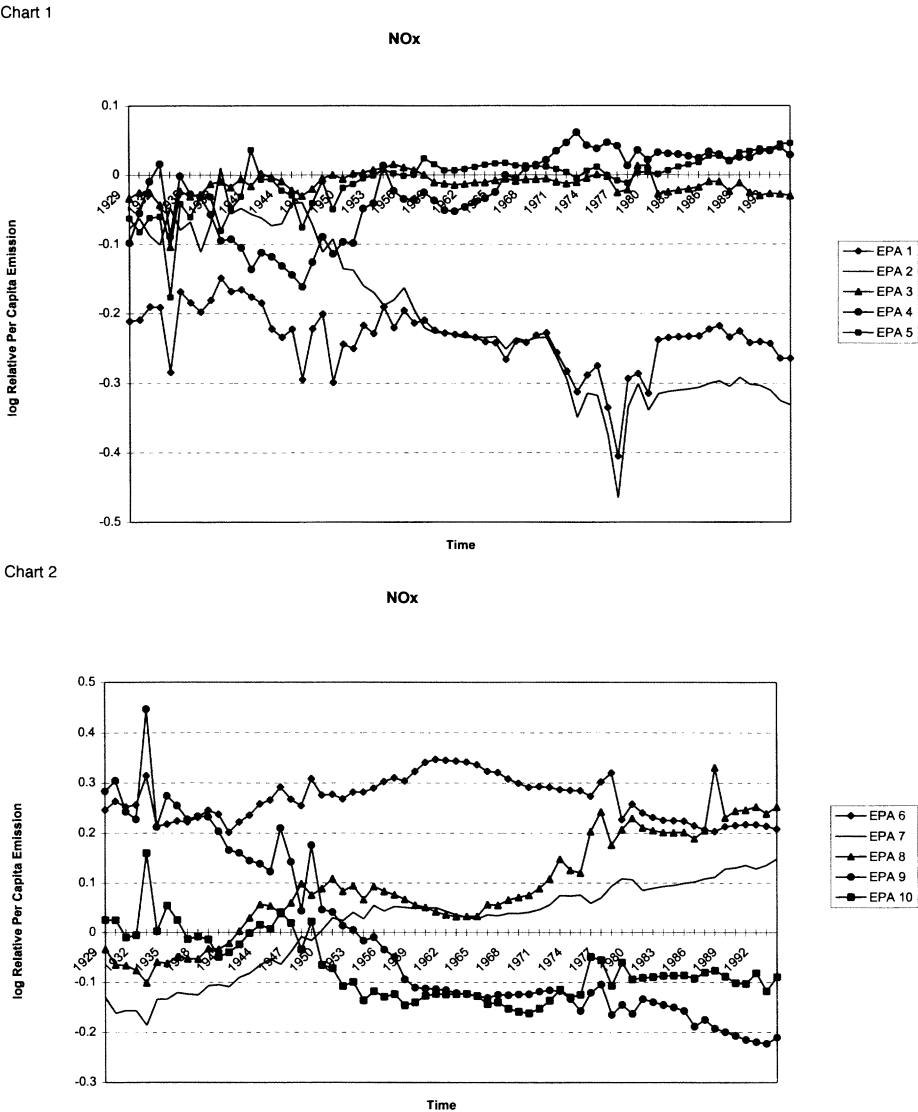


Figure 1. Trends of Relative Per Capita Emissions of NO_x and SO₂. Note: Trend is measured as the log relative per capita emission.

Cross-Sectional Convergence

To test for cross-sectional convergence, I use the technique called β -convergence that was developed by Baumol (1986). For our purposes, β -convergence tests whether regions having per capita emissions above their compensating differentials in 1929 had slower per capita emissions growth than those regions having per capita emissions below their compensating differentials in 1929. The Baumol (1986) empirical test of convergence involves estimating the following equation:

$$g_{pi} = \alpha + \beta E_{pio} + \epsilon_{pi} \tag{1}$$

Chart 3

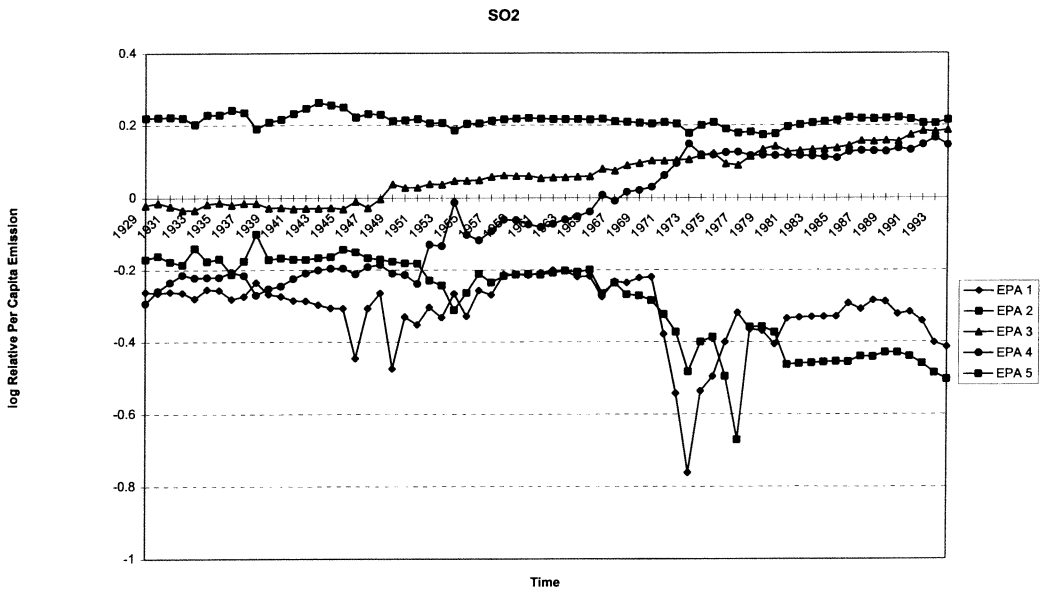


Chart 4

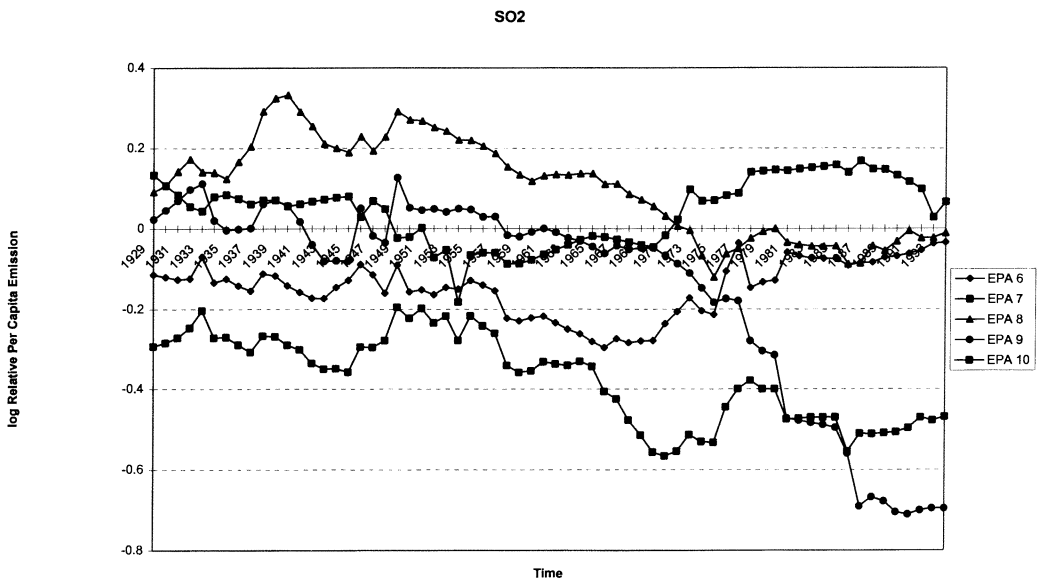


Figure 1. Continued

where g_{pi} is the growth rate in per capita emissions ($p = \text{NO}_x, \text{SO}_2$) in EPA Region i over the entire sample period, E_{pio} is the initial level of emissions per capita in Region i , ϵ_{pi} is the random error component, and α and β are estimated parameters. β -convergence is evident if $\beta < 0$, implying that regions with high initial levels of per capita emissions have lower emission growth rates than non-pollution-intensive regions. In Equation 1, emissions are measured in thousands of short tons.

Primary results from estimation of Equation 1 are:

$$\text{NO}_x \quad g_{pi} = 0.02 - 0.21E_{pio} \quad R^2 = 0.35$$

$$(3.2) \quad (-3.6) \quad (2a)$$

$$\text{SO}_2 \quad g_{pi} = 0.01 - 0.04E_{pio} \quad R^2 = 0.02$$

$$(1.1) \quad (-0.9) \quad (2b)$$

t-statistics are in parentheses beneath coefficient estimates.

The coefficient estimate of E_{pio} in Equation 2a suggests that per capita emissions of NO_x β -converged at the $p < .01$ confidence level. Although the results in Equation 2b imply that per capita emissions of SO_2 also β -converged from 1929 to 1994, β is not significantly different from zero at conventional levels. In terms of economic significance, parameter estimates in the NO_x (SO_2) regression indicate that for every 1000 short tons that a region's per capita emissions were above the national average in 1929, that region's growth rate of NO_x emissions was lowered by 0.21 percentage points per year during the 1929–1994 period, and the rate of SO_2 emissions was lowered by 0.04 percentage points during the same period. These results provide some evidence that per capita emission levels in non-pollution-intensive and pollution-intensive regions became more similar during the 1929–1994 period.⁶ However, given the numerous econometric shortcomings of the Baumol technique, emphasizing these findings alone would be inappropriate. For example, the Baumol technique is inefficient because it ignores intermediate data points in the sampling period. Thus, any trend in per capita emissions that occurs in intermediate years is completely lost when testing for β -convergence.⁷

Stochastic Convergence

Stochastic convergence among the 10 EPA Regions implies that the effects of temporary shocks dissipate over time, or, likewise, that the time series does not possess a unit root. If shocks to per capita emissions are permanent, then the time series has a unit root, and regions are not converging. Following Carlino and Mills (1996), I analyze the log of per capita emissions of one region relative to that of the economy as a whole. The log of relative per capita emissions in Region i at time t , RE_{it} , consists of two parts, the time invariant equilibrium differential, RE_i^e , and the deviations about this equilibrium,⁸ u_{it} :

$$RE_{it} = RE_i^e + u_{it} \quad (3)$$

where u_{it} is a stochastic process with drift:

$$u_{it} = c_0 + \epsilon_{it} \quad (4)$$

and c_0 is the initial deviation from equilibrium. Substituting Equation 4 into Equation 3 yields:

⁶ Testing for a Kuznets' (1955) curve and σ -convergence are other cross-sectional tests of convergence. I also computed the Gini coefficient and σ for each pollutant type. The Gini is defined as:

$$G = (1/2N^2\mu) \sum_i \sum_j |x_i - x_j|,$$

where N = number of states, μ is the overall mean of per capita emissions, and x_i represents per capita emissions for state i . Results imply that SO_2 followed an inverted U shape, whereas emissions of NO_x were not quadratic. Concerning σ -convergence, which considers the cross-sectional dispersion in per capita emissions, I find evidence supporting emission convergence for both pollutant types. All results are available upon request.

⁷ See Carlino and Mills (1996) for a good discussion of the numerous limitations of this technique.

⁸ The modeling of the time-series notion of time-invariant compensating-differentials equilibrium is similar to Carlino and Mills (1996).

$$RE_{it} = \mu + \epsilon_{it} \quad (5)$$

where $\mu = RE_t^c + c_0$. The time-series notion of stochastic convergence is contained in Equation 5: per capita emissions of a specific region are considered converging if the deviations, ϵ_{it} , are temporary.

The Augmented Dickey-Fuller (ADF) test for convergence is obtained by adding a simple lag operator to both sides of Equation 5 and including a lagged change in RE as a right-hand side variable (region subscripts suppressed):

$$\Delta RE_t = \mu + \alpha RE_{t-1} + \sum_{j=1}^k d_j \Delta RE_{t-j} + e_t, \quad (6)$$

where RE_t is the log of relative regional per capita emissions at time t , ΔRE_t represents the change in the log of relative regional per capita emissions, and ΔRE_{t-j} is the lagged change in the log of relative per capita emissions. Equation 6 is the standard ADF test for a unit root. If $\alpha = 0$, then shocks to relative regional emissions are permanent and emissions have a unit root, or follow a random walk. Interpretation of this result would be that regional per capita emissions have not converged. Instead, if $\alpha \neq 0$, then shocks to regional per capita emissions are temporary, the unit root null is rejected, and stochastic convergence is evident.

The lag length, k , is often set equal to 1 using the ADF approach. Recent evidence, however, suggests that an endogenous k is superior to choosing a fixed k (Loewy and Papell 1996). As such, I follow the procedure used by Perron (1989): start with an upper bound of $k = 8$, and use the approximate 10% value of the asymptotic normal distribution, 1.60, to assess the significance of the last lag, k . If the last included lag is significant, choose $k = 8$; if not, reduce k by 1 until the last lag becomes significant. If no lags are significant, set $k = 0$.

Empirical Results

The left panels of Table 1 contain estimation results of the ADF tests. The null hypothesis of a unit root is rejected if the t -statistic for α is greater (in absolute value) than the appropriate critical value. Critical t values for the ADF test, which appear in the notes to Table 1, are much larger in absolute value than standard t -ratios and are calculated based on MacKinnon (1991). Coefficient estimates in the left portion of the NO_x section of Table 1 suggest that per capita emissions of nitrogen oxides have converged conditionally in EPA Regions 3 and 10 at the $p < .01$ confidence level. The results for SO_2 are not as promising. Although Regions 1, 5, 6, 7, and 10 have t -ratios exceeding 1.5 in absolute value, estimates of t_α suggest that only Region 5 is converging at the conventional 5% statistical level.

These results provide some initial evidence that emissions have conditionally converged, but it is well known that stationarity tests ignoring the possibility of a structural break may cause nonrejection of the unit root null due to mis-specification (see, e.g., Perron 1989). In the present context, allowing for a structural break in the time path of emissions is particularly important given that the U.S. pollution regulatory structure changed during the sample period. Following Loewy and Papell (1996) and Zivot and Andrews (1992), among others, I allow for a one-time break in the trend of per capita emissions that is data dependent. The model estimated is Perron and Vogelsang's (1992) innovation outlier (IO) trend break model, which allows for intercept and slope changes in a gradual manner:

Table 1. Empirical Results for Nitrogen Oxides and Sulfur Dioxide^{ab}

Com-pound	EPA Region	ADF Tests			Sequential IO Trend Break Models			
		α	t_α	k	α	t_α	Break Year	k
NO _x	I	−0.23	−2.12	4	−0.39	−3.28	1942	4
NO _x	II	−0.03	−0.72	2	−0.15	−2.76	1947	2
NO _x	III	−0.45	−4.20***	0	−0.61	−7.69***	1933	0
NO _x	IV	−0.07	−1.23	1	−0.22	−3.13	1951	1
NO _x	V	−0.15	−1.67	7	−0.26	−2.51	1982	7
NO _x	VI	−0.13	−1.98	7	−0.10	−3.84	1978	7
NO _x	VII	−0.03	−1.56	5	−0.05	−2.88	1933	2
NO _x	VIII	−0.02	−0.60	2	−0.15	−2.40	1971	2
NO _x	IX	−0.05	−1.50	2	−0.08	−3.35	1933	2
NO _x	X	−0.18	−3.56***	4	−0.46	−5.79***	1949	4
SO ₂	I	−0.37	−2.54	7	−0.72	−4.10	1970	7
SO ₂	II	−0.01	−0.17	3	−0.59	−5.25**	1970	0
SO ₂	III	−0.01	−0.15	0	−0.06	−1.88	1947	2
SO ₂	IV	−0.01	−0.47	3	−0.02	−3.33	1971	3
SO ₂	V	−0.24	−2.90**	0	−0.43	−3.14	1947	8
SO ₂	VI	−0.10	−1.65	0	−0.19	−2.48	1975	2
SO ₂	VII	−0.09	−1.63	5	−0.19	−2.72	1970	5
SO ₂	VIII	−0.03	−1.10	1	−0.18	−3.33	1965	1
SO ₂	IX	−0.03	−1.21	4	−0.14	−2.64	1977	4
SO ₂	X	−0.07	−1.61	2	−0.64	−5.11**	1965	6

^a ***, statistically significant at the 1% level, **: statistically significant at the 5% level, and *: statistically significant at the 10% level.

^b Critical values for the ADF test were as follows: −3.53 for 1%, −2.90 for 5%, and −2.59 for 10%. Critical values for the IO Trend Book Model were as follows: −5.51 for 1%, −4.76 for 5%, and −4.42 for 10%.

$$\Delta RE_t = \mu + \alpha RE_{t-1} + \sum_{j=1}^k d_j \Delta RE_{t-j} + \phi D(T_B)_t + \eta Du_t + e_t,$$

(7)

where ΔRE_t , μ , RE_t , RE_{t-1} , and ΔRE_{t-j} are as defined above, T_B is the estimated break date, $D(T_B) = 1$ if $t = T_B + 1$, and 0 otherwise; $Du_t = 1$ if $t > T_B$, and 0 otherwise.⁹ The endogenous trend break is implemented by estimating Equation 7 sequentially for each break year $T_B = k + 2, \dots, T - 1$, where T is the number of observations, and the year (T) that minimizes the t -statistic for α is considered the break year. The lag length, ΔRE_{t-j} , is chosen by using the endogenous k method described above. As in the ADF test, the unit root null is rejected if the t -statistic for α is greater (in absolute value) than the appropriate critical value. I use the $T = 50$, $k(t)$ critical values provided in Perron and Vogelsang (1992, their Table 2).

Results of the IO trend break models are in the right panels of Table 1. A first issue regards the estimated break years presented in column 7. The estimated trend breaks in the NO_x emission models are intuitively appealing, as eras of the Great Depression, World War II, and the environmental movement of the 1970s serve as endogenously determined break years. This finding illustrates the importance of the added generality of the IO model. Coefficient estimates from the NO_x regression models suggest that Regions 3 and 10 have conditionally converged at the

⁹ Since equations 6 and 7 do not contain a time trend, the alternative hypothesis is a level stationary series.

1% significance level. Although t_α in the other EPA Regions does not exceed the appropriate critical values, all of the remaining 8 regions have t_α (absolute) values greater than 2.40. These findings provide some evidence that emissions of NO_x have conditionally converged in the U.S. during the 1929–1994 period.

The right panel of the SO_2 section of Table 1 contains estimation results for emissions of sulfur dioxide. The estimated break years for SO_2 are primarily around 1970, as 7 of the 10 EPA Regions have a structural break between 1965–1975. This finding again illustrates the importance of allowing the emission paths to have a structural break and suggests that the trend of SO_2 emissions significantly changed during the great environmental movement. This finding is reasonable, because the original Clean Air Act in 1963 and the first Clean Air Act Amendments in 1970 targeted large Class A emitters of SO_2 . Estimated t -ratios in Table 1 provide evidence of emission convergence in EPA Regions 2 and 10 at the 5% significance level. In addition, four of the other EPA regions have t_α values exceeding three in absolute value. For SO_2 , the added generality of the trend break model appears to pay off as the empirical results from the IO model provide more evidence against the unit root than the standard ADF tests.

Given that the power to reject the unit root null remains relatively low in these estimation procedures, these findings provide some evidence that one indicator of environmental quality—air pollutant emissions—has conditionally converged across regions in the U.S. These results significantly strengthen previous income convergence findings and do not refute the conjecture that “green incomes” have converged in some EPA Regions. From a Pareto viewpoint, these findings move us one step closer to the tantalizing possibility that overall welfare levels are conditionally converging in the U.S.

Policy Implications

Given the continued interest in devolving formerly federal government operations onto state and local governments, interjurisdictional competition has become a central issue in local public finance. Although a key underlying premise of U.S. environmental policy from 1963 through the early 1980s was that if states were allowed to do so, they would compete with each other for industry by compromising enforcement,¹⁰ these findings provide evidence that states may not be interested in “racing to the bottom” by adopting weaker environmental regulations or by compromising enforcement to attract mobile capital.

In a related vein, if emission convergence is a repercussion of environmental policy convergence, these results may provide an explanation for the recent findings in the firm location literature. Although conventional wisdom implies that economic growth and environmental quality are incompatible policy objectives, recent empirical evidence suggests that stringency of environmental regulation is only weakly (or not at all) associated with decreased manufacturing activity (List 1998). One plausible explanation for this counterintuitive result is that while compliance expenditures have steadily risen, environmental policies have become more similar across space, confounding any effects of increased environmental compliance expenditures. Consequently, if federal budgets continue to tighten, the empirical results above may suggest an expanded future role for state and local governments in providing environmental protection.

¹⁰ A cornerstone of the Clean Air and Water Acts of the early 1970s was that “[t]he promulgation of [f]ederal emission standards for new sources. . . will preclude efforts on the part of [s]tates to compete with each other in trying to attract new facilities” (U.S. House 1979).

4. Concluding Remarks

Recent studies of income distribution have found evidence supporting the neoclassical theory of income convergence. Whether income convergence implies that standards of living have become more similar is an open issue because “green incomes,” or income levels adjusted for environmental quality, may be diverging. This paper uses data on per capita emissions of nitrogen oxides and sulfur dioxides to test if one indicator of environmental quality has converged across U.S. regions from 1929 to 1994. Empirical results from unit root tests provide some evidence that per capita emissions of nitrogen oxides and sulfur dioxides have conditionally converged across the 10 EPA Regions. These results strengthen previous income convergence findings and do not refute the conjecture that “green incomes” have converged across U.S. regions. In addition, certain empirical results provide an appealing explanation for the extant literature that suggests that the stringency of environmental regulations is only weakly associated with decreased manufacturing activity, even though pollution compliance expenditures have steadily risen since the early 1970s.

Future research is warranted. Although numerous indicators of environmental quality are important, this paper focuses on only one attribute of the amenity base of a region. Other measures of environmental quality, such as ecosystem and species preservation, regulatory expenditures to monitor polluters, or pollution concentration levels, represent viable proxies that could be used in lieu of emissions. Another potential extension is a cross-country analysis. Since many intercountry studies indicate that incomes are converging, from a welfare standpoint, “real” convergence again becomes an important issue.

Appendix: Environmental Protection Agency Regions

Region 1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Region 2	New Jersey, New York
Region 3	Delaware, Maryland, Pennsylvania, Virginia, West Virginia
Region 4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
Region 5	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
Region 6	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
Region 7	Iowa, Kansas, Missouri, Nebraska
Region 8	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
Region 9	Arizona, California, Nevada
Region 10	Idaho, Oregon, Washington

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