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AMBIENT AIR QUALITY AS RELATED TO ENERGY CONVERSION FACILITIES, ECONOMIC ACTIVITY AND POPULATION

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Abstract

The paper examines the relationships between ambient air quality and energy conversion facilities, economic activity and population. Additional results are presented from investigation of the relationship between ambient air quality and total emissions from four source categories.

This paper reports some preliminary results of ongoing research on statistical explanations of observed ambient air quality.

We examine three separate questions in this paper: (1) If control regions were defined with respect to air quality in selected SMSA's, would the resulting regions correspond to existing EPA regions?, (2) do selected indices of economic activity, population and the concentration of energy conversion facilities in selected SMSA's explain a significant amount of the variation in ambient air quality among the selected SMSA's?, (3) if we rank-order AQCR's with respect to total emissions and ambient air quality, do we observe a relationship between the two sets of observations and to what extent can ambient air quality be explained with reference to sources of emissions?

Figure I lists the 29 SMSA's examined together with the corresponding AQCR number. There are only 27 observations as two pairs of SMSA's are collapsed. Data for the early 1970's on SMSA population density, manufacturing employment (%), wholesale/retail employment (%), and construction employment (%) were taken from Commerce's <u>County and City Data Book</u> (1) and 1973 electric utility emissions in the SMSA's were taken, at the plant level, from FPC reports (3). 1976 emissions by source category and ambient air quality (particulates and SO_2) data were taken from EPA documents (2).

Questions 1 and 2 above are dealt with using techniques of cluster analysis and linear regression. The data for these analyses was for 1972 and 1973.

Figure I

SMSA's and AQCR's*

SMSA	AQCR
Allentown PA	151
Atlanta GA	56
Baltimore MD	115
Birmingham AL	4
Boston MA	119
Buffalo NY	162
Charleston WV	234
Charlotte NC	167
Chattanooga TN	55
Chicago IL	67
Cincinnati OH	79
Cleveland OH	174
Columbus OH	176
Denver CO	36
Detroit MI	123
Gary-Hammond IN	67
Los Angeles CA	24
Milwaukee WI	239
Nashville TN	208
New Orleans LA	106
New York NY	43
Philadelphia PA	45
Pittsburgh PA	197
At. Louis MO	70
San Francisco CA	30
Seattle WA	229
Tacoma WA	229
Washington DC	47
Youngstown OH	178

*In most cases AQCR's are larger than SMSA's. Only ambient air quality data for the SMSA portions of AQCR's was used.

The third question was handled using both linear regression and rank-order correlation techniques. For both analses, 1976 data was used.

For questions 1 and 2 we are interested in (1) spatially structuring SMSA's with respect to ambient air quality, and (2) seeing if the air quality experience across SMSA's can be adequately explained with reference to indices of economic activity and the concentration of energy conversion facilities (electric generation) in each SMSA region. We used emissions from all power plants in given SMSA's together with those in contiguous counties. Because we are dealing with relatively small geographic areas (SMSA's), we are assuming short-range transport of airborne residuals (50 miles or less). For the first question, then, we take ambient air quality with respect to SO_2 and particulates and use cluster analysis (see 4 for technical details) to "group" SMSA's according to air quality. Figures II and III show the clustering of SMSA's according to pollution experience. From a policy and efficiency perspective, each grouping suggests a set of SMSA's which could, in principle, be examined and regulated in a common manner. The reader will observe that the SMSA's in each group "cross" EPA regional boundaries suggesting the present spatial make up of EPA administrative regions is not optimal with respect to regulation of air borne residuals. That this is the case has been recently recognized with

Figure II

CLUSTER ANALYSIS RESULTS: SO_2
6 Clusters with Ratio = .67

Cluster No.	SMSA's
1	Allentown PA Buffalo NY Philadelphia PA Charleston WV Washington DC New York NY
2	Atlanta GA Detroit MI Gary-Hammond IN Boston MA Los Angeles CA Milwaukee WI Baltimore MD Tacoma WA Columbus OH Chicago IL Cincinnati OH
3	Cleveland OH Youngstown OH St. Louis MO
4	Pittsburgh PA
5	Birmingham AL San Francisco CA New Orleans LA
6	Charlotte NC Nashville TN Denver CO Chattanooga TN Seattle WA

respect to air quality in the Ohio River Basin which includes portions of three EPA regions. Recent EPA efforts have been initiated for interdistrict cooperation in order to handle this air quality spatial problem.

Figure III

CLUSTER ANALYSIS RESULTS: PARTICULATES
6 Clusters with Ratio = .56

Cluster No.	SMSA's
1	Allentown PA Cincinnati PA Baltimore MD Columbus OH Detroit MI Milwaukee WI Philadelphia PA
2	Birmingham AL Cleveland OH Chicago IL Gary-Hammond IN Charleston WV
3	Atlanta GA Charlotte NC New York NY Seattle WA Tacoma WA
4	Boston MA Buffalo NY New Orleans LA Chattanooga TN Nashville TN San Francisco CA Washington DC
5	Los Angeles CA Pittsburgh PA St. Louis MO Youngstown OH
6	Denver CO

Regarding question 2, we regress ambient air quality (SO_2 and particulates) on selected economic and demographic variables and on the emissions from generating facilities to determine the amount of variation in air quality across SMSA's which can be explained by these variables. It must be emphasized that no engineering dispersion or transport model is used in the exercise. It is assumed that the radius of each SMSA region is sufficiently large to take in short-range dispersion. Because the results for SO_2 and particulates are qualitatively similar, we report only regression results for particulates. These are found in Figure IV. In general, the reported results are very strange and inexplicable. Not only is the amount of variation across SMSA's explained by the variables very small (27%), but the signs on several estimated coefficients are contrary to *a priori* arguments. Population diversity (a surrogate for mobile emission sources), for instance, has a negative sign and is of extremely low absolute value. Somewhat encouraging, however, are the signs and t-values for manufacturing employment (a surrogate for intensity of fuel combustion concentration) and electric utilities emissions; both are positive, although neither statistically significant. In general, ambient air quality across this group of SMSA's is not well explained with reference to conventional variables and, indeed, the direction of influence for certain surrogate variables is inexplicable.

Figure IV

REGRESSION RESULTS FOR PARTICULATES:
SMSA's

Parameter	Estimate	t-values
Intercept	74.3	1.34
PD	-0.0007	-0.22
MD	.65	1.5
WR	-1.11	-0.57
CON	-1.005	-0.23
E1	.127	.81

R - square = .269

PD=population density
MG=manufacturing employment(%)
WR=wholesale/retail employment(%)
CON=construction employment(%)
E1=emissions from electric utilities

Finally, we statistically explore, for AQCR's in 1976, relationships between total emissions by source and ambient air quality. These results are reported in Figures V and VI.

Figure V reports the results of rank order correlation (see 6 for technical details) between total emissions and ambient air quality (SO_2 and particulates) in the AQCR's. For short-range transport, one might expect AQCR's with large total emissions to also experience relatively poor air quality (high SO_2 and particulate readings). For that reason, rank-order correlation is the appropriate technique to explore that hypothesis. From Figure V, it will be noted that the correlations for both particulates and SO_2 are quite low (.43 and .33 respectively), although both are significant. This suggests, of course, that emissions and ambient air quality are probably not well correlated across SMSA's if one takes into account only short-range transport assumptions.

Figure V

RANK ORDER CORRELATIONS OF
TOTAL EMISSIONS AND AMBIENT AIR QUALITY
IN SELECTED AQCRs

Correlations	Coefficient	t value
Particulate emissions and air quality	.4325	2.3988*
SO_2 emissions and air quality	.3327	1.7641**

NOTES: * significant at 2.5%
** significant at 5%

Figure VI reports the regression results for SO_2 where AQCR's ambient air quality is regressed on total emissions by sources. The sources are fuel combustion, transportation, solid waste and industrial production. Space does not permit reporting the results for particulates, although the R-square is smaller but the estimated coefficients similar. From Figure VI it will be observed that (1) the amount of variation in air quality across the 27 AQCR's explained by the emission sources is very small (28%), and (2) the absolute values of certain coefficients as well as their signs are contrary to conventional expectations. For instance, conventional arguements suggest industrial production emissions would be positively related to ambient air quality (large SO_2 readings), yet from Figure VI the sign on the coefficient is negative. Further, one expects fuel combustion emissions to be significantly related (and of positive sign) to SO_2 readings. While the sign of the coefficient is correct in Figure VI, the estimated coefficient value is extremely small (.0001) and is not significant (t-value of .06).

Figure VI

REGRESSION RESULTS: AIR QUALITY
ON EMISSIONS: SO_2

Parameter	Estimate	t-values
Intercept	76.22	8.58
FC2	0.0001	0.06
TN2	.00001	1.43
SW2	-0.00008	-0.13
IP2	-0.003	-0.38

R - square = .284

FC2=fuel combustion emissions
TN2=transportation emissions
SW2=solid waste emissions
IP2=industrial production emissions

The results reported in Figures IV - VI, then, suggest conventional or *a priori* notions concerning relationships between population, economic activity, and energy conversion facilities and ambient air quality cannot be verified in the context of assuming short-range transport of airborne residuals. Aside from the usual questions regarding the adequacy of air quality monitoring, there would appear to be, at a minimum, two possible explanations for these results. First, inclusion of engineering equations for short-range dispersion and mixing might alter the results. Second, short-range transport of airborne residuals may be an inadequate explanation for transport or dispersion of airborne residuals. Based on the existing and ongoing long-range transport work of Technekron, Inc. for EPA-ORBES (5), the latter explanation seems the most likely. That is to say, a significant determinant of air quality in, say, Allegheny County, PA, is the economic activity and electric generating facilities in the lower Ohio Valley, say 200-300 kilometers away from Allegheny County. Work is in progress which models the long-range transport influence on ambient air quality in a given air "corridor."

1. References

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2. Biography

Walter Page is on the faculty, Department of Economics, West Virginia University. His primary research interests and publications are in the areas of energy and environmental economics. He is currently on a grant with the Environmental Protection Agency ("Ohio River Basin Energy Study") modeling coal supplies to the year 2000 for the Ohio River Basin. He also serves as a consultant to the Energy Division, Oak Ridge National Laboratory.