VARIATIONS IN ENVIRONMENTAL QUALITY INDICATORS IN LARGE METROPOLITAN AREAS

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I. Introduction

Dissatisfaction over land use, natural resources extraction, and pollution damage to our natural environment by industrialization and urbanization has been growing in this country. According to the estimate of the Council on Environmental Quality [12], a total of $200 billion will be spent on pollution control between now and 1980 in order to maintain present air and water quality standards. Since resources are finite and environmental protection or pollution control is costly, it is necessary to ascertain that the last unit of control bought imposes no additional costs greater than the additional benefits.

As Fisher and Peterson [4] have pointed out, not only is the policy of internalizing not generally relevant to the management of natural environments (and direct government intervention is required since there are no market mechanisms to rectify), but also most of our advice cannot be implemented without gathering a great deal of useful information, of which very little already exists. One of the most detrimental features of the social sciences to date has been the absence of any generally agreeable and acceptable consensus set of either social welfare functions or social conditions. In addition, a problem is not likely to be solved until it has been perceived and identified as a problem. Although there exist thousands of decisionmakers within the private sector who are able and willing, and devoted to the enhancement of our environmental quality of life, they are not certain about the direction that their activities should take, just as many public decisionmakers are not always sure about the social, economic, political, and environmental impacts of their actions. In order to promote the general welfare and to enrich the environmental quality, there is an urgent need for a mechanism which can distinguish better from worse as stressed by Anderson [1], Bauer [2], Cohn [3], Fox [5], Sheldon and Moore [13], Sheldon and Parke [14], et al. As it now stands, the United States has neither a comprehensive set of social statistics that reflect changes in our values and measure social progress or retrogression, nor an integrated set of environmental indicators which can describe the environmental conditions and evaluate all environmental protection policies among the standard statistical metropolitan areas (SMSA's).

The search for environmental indicators is an attempt to obtain consistent information that will be useful to evaluate the past, guide the action of the present, and plan for the future. The empirical measures of various levels of environmental quality of life presented in this paper are aimed at the identification of strengths and weaknesses.

II. An Environmental Quality Model

Although it is generally understood that the need for environmental quality indicators is urgent because they are essential to the assessment of many aspects of social progress and social accounting, and are useful for national goal setting, project planning, priority ranking, program manipulation, and performance evaluation, there is no consensus as to what environmental quality is all about, how the quality indicators should be defined, and for whom and in what manner they should be constructed. This failure to reach a consensus can be substantially attributed to the absence of a commonly accepted social welfare function or value system.

Methodological development of environmental indicators and interest in the environmental quality concept development grew remarkably in the 1960's. The National Wildlife Federation has constructed Environmental Quality Indexes since 1969. Furthermore, the Environmental Protection Agency has been generating a variety of air, water and solid waste, and other environmental pollution indicators in the U.S. Instruction and model specifications in measuring environmental quality and impacts were given in the interim guidelines for implementing the National Environmental Policy Act (NEPA) in April 1970, by the Council on Environmental Quality, which since 1970 has been submitting to the President an annual report, Environmental Quality.

Although the Council on Environmental Quality (CEQ) was authorized to promote the development of indexes and monitory systems to determine the effectiveness of programs for protecting and enhancing environmental quality to sustain and enrich human life, the reports issued by CEQ have not reported environmental indicators in any form comprehensive enough for detailed regional analyses. Consequently, reviewers such as Mills and Peterson [10,267] have stressed that the CEQ should accord high priority to development of an adequate statistical appendix.

The model employed in this paper is taken from the one developed by the author [6] and is termed the quality of life production model. Given that the quality of life means happiness or a state of satisfaction and that the quality of life indicators represented by a set of statistics on economic, political, environmental, health and education, and social conditions may offer clues to human attitudes and behavior and social performance over time, the quality of life that each individual (i) attempts to maximize may be expressed as an output function with two factor inputs as arguments--the physical (PH) and the psychological (PS)--a portion of which he owns and shares with other people in the community at any given point of time (t):

$$QOL_{it} = f\ (PH_{it},\ PS_{it})$$

The physical input consists of quantifiable goods, services, material wealth, etc., while the psychological input includes all subjective, spiritual, sociological, and anthropological factors such as community belongingness, esteem, self-actualization, love, affection, etc. Although the production function expressing the relationship between output and input factors of quality of life is known to be enormously complex (there are as many such factors as there are people), an aggregate homogeneous production function may be assumed for a metropolitan area as a whole. Since the psychological inputs are not readily quantifiable and hence rarely reported, the quality of life output may be taken at a particular point in time as a function of those social (SO), economic (EC), political and welfare (PW), health and education (HE), and environmental (EN) inputs which are quantifiable or:

$$QOL_{it} = F(EC_{it},\ PW_{it},\ EN_{it},\ HE_{it},\ SO_{it}\quad PS_{it})$$

The model proposed here is similar to the conventional production models employed to study the behavior of firms. The two axes, instead of being labeled as capital and labor per unit of time, are, respectively, the ordinal measures of the psychological inputs and the cardinal measures of the physical inputs. The iso-quant curves are hereby replaced by the iso-quality of life curves, and the budget lines are substituted for by the individual's capability curves which, in this case, would likely be concave to the origin. The optimal level of quality of life is produced only by combining both the physical and psychological inputs in such a form as to locate the tangency point between the iso-quality and the capability constraints to exchange and to acquire, while the major concern for a society is how to improve an individual's capability by shifting the constraint curve outward to the right.

To measure objectively the output level of quality of life as subjectively perceived by individuals, we may start with the cardinal measures of the physical inputs by holding constant the psychological inputs. Given this, an environmental model ideally should take into account factors other than pollution, climate, and recreational facilities such as natural endowments and conservation, resource availability and accessibility, etc. However, the scarcity of comparable data for SMSA's prevents those representative variables from being selected and included. Thus, the environmental model in this paper encompasses only such variables affecting our urban quality of life as the air, visual, noise, solid waste and water pollution, climatological and recreational factors. All types of pollution are grouped under the individual and institutional environment because they are different by-products of various human activities.

The other quality measure in this model is the natural environment component which includes five climatological variables and two recreational variables: sunshine days, inversion frequency, thunderstorms, high and low temperatures, areas of parks and recreational areas, and miles of trails. Parks and recreational areas have come to play an ever-increasing, important role in our city life. As a result, this variable is used twice in the environment component, serving as a determinant of visual pollution and a factor of natural environment as well.

All variables, except the parks and recreational areas, miles of trails, and sunshine days, in this paper have adverse effects on our environmental quality, and are negative inputs to our daily life. Thus, 17 variables mentioned depict mostly our urban environmental "bads" rather than "goods." They are chosen for the following reasons: they make us alert to our environmental problems, compare the quality of our environment, and judge the efforts made to reduce and eliminate the pollutants. It should be noted, however, that evidence suggests that the direct effects of pollution on property, on human health, and on the quality of life are varied [7,9,15].

Among the individual concerns in our environmental quality, this model is thus identified with the determinants made up of individual and institutional environments (IIE) and natural environment (NE). While the former set of variables are entirely strategical and policy-oriented variables, the latter include most uncontrollable inputs of climate considerations, i.e.,

$$EN_{it} = f(IIE_{it},\ NE_{it})$$

While some variables are represented by published official sources, some are denoted in the firsthand 1970 data collected and computed by the author [6]. The data for 1970 were collected for the 65 large SMSA's with populations between 500,000 and 1,000,000, and the standardized "Z" values were computed for all factors. On the basis of the percentile distribution of the "Z" values, SMSA's were divided into five groups and assigned points of 5, 4, 3, 2, or 1, respectively, for outstanding (A); excellent (B); good (C); adequate (D); and substandard (E). Factors within the same subcategory were then weighed equally to derive a subcategory score, and the subcategory scores were weighed equally to obtain a subcomponent score. Finally, the average of the subcomponent scores was taken to show the composite index for each SMSA, which was subsequently rated by the indexes in comparison with those of other SMSA's.

III. Empirical Results

The environmental quality of life indicators in this study concern both individual and institutional environment and natural environment. Air, visual, noise, water, and solid waste pollution are by-products of the postindustrialized society. Their existence and the attempts at eradication not only impose a heavy financial burden on our society, but they are also hazards to human health, animal fertility, crop production, etc. Thus, relative indicators for these five categories were constructed based on the absolute indicators obtained from various public and private sources. The individual and institutional environments among the metropolitan areas are evaluated jointly on 10 different factors.

The natural environment is evaluated from five climatological and two recreational factors. The factors included in this component are fewer than desirable and are far from being complete because of the lack of empirical statistics. Nevertheless, these factors provide basic information for a fairly accurate judgment on urban environment for all metropolitan areas. Table 1 presents all statistical results. The most important findings in this study and their implications are broadly delineated in the following:

1. This study of environmental quality in large SMSA's indicates that the Pacific region stands at the top of the listing. All but two SMSA's in the Pacific region are rated either "outstanding" or "excellent." In fact, California has four outstanding SMSA's, or about 40.0 percent of the total of 11 rated "A." They are Sacramento, San Bernadino-Riverside-Ontario, San Diego and San Jose. However, Los Angeles-Long Beach and Anaheim-Santa Ana-Garden Grove SMSA's fall only in the average category. The best of "A"-rated SMSA's is Sacramento which obtained an environmental quality index appreciably greater than the others; i.e., -0.20 or about two standard deviations above the mean of -1.03. Next to Sacramento in environmental quality is Seattle-Everett. Portland SMSA ranked ninth in the race for better environment quality. The other "A"-rated SMSA's are Miami, Honolulu, Phoenix, Allentown-Bethlehem-Easton, other "A"-rated SMSA's are Miami, Honolulu, Phoenix, Allentown-Bethlehem-Easton, and Springfield-Chicopee-Holyoke.

The geographic distribution of ratings shows also the existence of a concentrated pattern among the SMSA's that received unfavorable ratings. Many large SMSA's in the East North Central and Middle Atlantic regions were rated either substandard or only adequate. However, the lowest environmental rating among the 65 SMSA's was found in Pittsburgh. This resulted primarily from its extremely high level of total suspended particulates, visual and water pollution.

Chicago SMSA has the second lowest index, -1.82. This SMSA had a number of environmental problems, but its water and air pollution was among the worst. While Anaheim-Santa Ana-Garden Grove SMSA has water pollution indexes as low as 0.68, Chicago had an index of about 26 times as high as the best area in California. In addition, this SMSA also suffered from a lack of recreation areas and facilities.

2. Although there is a clear pattern of the distribution of the environmental quality indexes among regions, the overall variation in environmental quality among the large sized SMSA's does not appear to be very critical. Except for the SMSA's mentioned in the preceding section, most of the remaining SMSA's received quality indexes which are not significantly different from each other in aggregate values; the coefficient of variation is about 0.34 (0.345/1.034). This environmental inequality problem in the large SMSA's is relatively more serious than that in the medium or small sized SMSA's. Nevertheless, the environmental inequality problem among these 65 SMSA's is much less discernible than the social inequality problem as observed in the SMSA's. For a paper on social quality, see Liu [9].

3. Although it is normally expected that the levels of objectively measured environmental quality vary from region to region and from component to component, it is very interesting to note that only a few of the 65 SMSA's have consistently high or low ratings among all factors under consideration. For instance, even though San Bernadino-Riverside-Ontario ranked first in the natural environmental quality, this SMSA showed serious visual and noise pollution and solid waste problems. The most serious problem in Houston was the insufficient recreation areas and facilities--it ranked 53rd. On the contrary, the SMSA's rated substandard on the overall scale also showed comparatively favorable ratings in many environmental considerations. For instance, Cleveland compared very well in visual and noise pollution and in parks and recreational areas; Detroit ranked 14th in visual pollution and Indianapolis 17th in noise pollution and 33rd in parks and recreational areas; and Louisville even scored 3rd in solid waste generation.

4. Pollution and environmental damages have been increasingly attacked by opponents to economic growth and industrialization. Economists have aptly used pollution as an illustration of externalities. The trade-off between economic activities and environmental deterioration, or the degradative changes in our ecosystem, have been generally accepted. The author observed

that the trade-off phenomenon seems to be more significant in the large sized metropolitan areas than in the medium sized areas. Chicago ranks as an SMSA with substandard environmental quality, but outstanding economic health. Honolulu and Springfield-Chicopee-Holyoke were revealed to be opposite cases. The third typical case was found in Portland, where both economic and environmental quality was outstanding in 1970.

5. The Spearman rank order correlation coefficient (r) obtained between the individual and institutional (IIE) and the natural environmental component (NE) for the 65 SMSA's is 0.17, indicating that there is virtually no correlation between the two components employed for environmental quality evaluation among regions. In addition, this finding tends to be supportive of the basic prerequisite in the development of social indicators, that the selected variables should be as independent of each other as possible.

IV. Implications and Concluding Remarks

Empirically the model systematically evaluated the varying environmental elements among the U.S. urban areas, and constructed the first set of environmental quality indexes for the nation's large metropolitan areas.

While geographically this paper found a concentration pattern of environmental inequality in favor of the Pacific and against the East North Central and Middle Atlantic regions, this inequality problem among the 65 large sized SMSA's is not as serious as other quality of life components such as social, health and education. However, the trade-off hypothesis between economic growth or industrial development and environmental degradation has been observed in many cases among the large SMSA's, especially those in the manufacturing regions. The implication of those findings is that on the whole, people in the large SMSA's were still enjoying a relatively homogeneous environmental quality of life as of 1970. Policies probably would be better to focus on the preservation of this homogeneity in general and the improvement in the substandard North Central and Middle Atlantic regions in particular.

This paper has also found that in this country there is neither a perfect SMSA offering the best of environmental quality nor a worst area suffering substandard environmental illness in all 17 institutional and natural environment considerations. For policy decisionmakers, it indicates that there is always an area (or areas) requiring special attention and extra effort in order to balance the overall environmental quality of life within each SMSA. The environmental well-being is a notion for multidimensional concepts. Thus, at the present time it is not only theoretically controversial to consider a sole indicator for the overall environmental quality, it is also empirically difficult to single out an index for the environmental measurement due to the lack of consensus in weighting between the institutional and the natural components.

Since there are definite regional concentration patterns and inequalities in the environmental quality, a more thorough investigation of input factors in the adequate or substandard regions should reveal the cause-effect relationship, and the potential trade-offs between economic and environmental objectives. Consequently, better policy alternatives and feasible remedies may be recommended.

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Table 1

ENVIRONMENTAL QUALITY OF LIFE INDICATOR RATING AND RANKING FOR LARGE SMSA'S 1970

	Overall	Individual and Institutional Environment (IIE)	Natural Environment (NE)
Akron, Ohio	-.9667 C 23	-2.4333 C 23	0.5000 C 25
Albany-Schenectady-Troy, N.Y.	-1.2917 D 53	-2.6333 D 46	0.0500 D 30
Allentown-Bethlehem-Easton, Pa-N.J.	-.6167 A 9	-1.9333 A 2	0.7000 B 14
Anaheim-Santa Ana-Garden Grove, Ca.	-1.0500 C 33	-2.7000 D 50	0.6000 B 20
Atlanta, Ga.	-1.2833 D 52	-2.4667 C 35	-0.1000 E 58
Baltimore, Md.	-1.2667 D 50	-2.7333 D 52	0.2000 D 41
Birmingham, Ala.	-1.4250 E 59	-2.7000 D 51	-0.1500 E 59
Boston, Mass.	-1.2500 D 48	-3.0000 E 53	0.5000 C 24
Buffalo, N.Y.	-1.2000 D 45	-2.5000 C 37	0.1000 D 48
Chicago, Ill.	-1.8167 E 64	-3.3333 E 61	0.3000 E 64
Cincinnati, Ohio-Ky.-Ind.	-1.0333 C 30	-2.1667 B 8	0.1000 D 47
Cleveland, Ohio	-1.4250 E 60	-3.2000 E 62	0.3500 C 35
Columbus, Ohio	-1.0917 C 38	-2.4333 C 31	0.2500 D 38
Dallas, Texas	-.9083 B 21	-2.2667 B 16	0.4500 C 29
Dayton, Ohio	-1.3167 D 56	-3.1333 E 60	0.5000 C 23
Denver, Colo.	.9917 C 24	-2.6333 D 47	0.6500 B 15
Detroit, Mich.	-1.7250 E 63	-3.4000 E 64	0.0500 D 55
Fort Lauderdale-Hollywood, Fla.	-1.0833 C 36	-2.7667 D 53	0.6000 B 19
Fort Worth, Texas	.8583 B 18	-2.1667 B 9	0.4500 C 28
Gary-Hammond-East Chicago, Ind.	-1.1750 D 43	-2.3000 B 23	0.0500 D 54
Grand Rapids, Mich.	-1.0333 C 31	-2.2667 B 17	0.2000 D 40
Greensboro-Winston-Salem-High Point, N.C.	-1.3000 D 54	-2.4000 B 28	-0.2000 E 63
Hartford, Conn.	-1.1250 C 40	-2.5000 C 38	0.2500 C 37
Honolulu, Hawaii	-.4583 A 4	-2.0667 A 4	1.1500 A 10
Houston, Texas	-1.0000 C 26	-2.1000 A 5	0.1000 D 46
Indianapolis, Ind.	-1.5250 E 61	-3.2000 E 63	0.1500 D 43
Jacksonville, Fla.	-1.2500 D 49	-2.3000 B 24	-0.2000 D 62
Jersey City, N.J.	-1.0167 C 27	-2.4333 C 32	0.4000 C 33
Kansas City, Mo. - Ks.	-1.1250 C 39	-2.3000 B 25	0.0500 D 49
Los Angeles-Long Beach, Ca.	-1.0583 C 34	-2.9667 E 57	0.8500 D 13
Louisville, Ky.-Ind.	-1.4167 E 58	-2.9667 E 57	-0.2000 E 61
Memphis, Tenn.-Ark.	-1.2083 D 47	-2.3667 B 26	-0.0500 D 53
Miami, Fla.	-.4167 A 3	-2.4333 C 33	1.6000 A 4
Milwaukee, Wis.	-1.0417 C 32	-2.2333 B 13	0.1500 D 42
Minneapolis-St. Paul, Minn.	-.9000 B 20	-2.1000 A 6	0.3000 C 36
Nashville-Davidson, Tenn.	-1.0833 C 37	-2.2667 B 18	0.1000 D 45
New Orleans, La.	-1.2667 D 51	-2.5333 C 42	0.0000 D 51
New York, N.Y.	-1.3333 D 57	-3.0667 E 59	0.4000 C 32
Newark, N.J.	-1.2000 D 46	-2.8000 D 55	0.4000 C 31
Norfolk-Portsmouth, Va.	-.8667 B 19	-2.2333 B 14	0.5000 C 22
Oklahoma City, Okla.	-.8250 B 15	-2.2000 B 10	0.5500 C 21
Omaha, Nebraska-Iowa	-1.3083 D 55	-2.5667 C 44	-0.0500 D 52
Paterson-Clifton-Passaic, N.J.	-1.0000 C 25	-2.4000 B 29	0.4000 C 30
Philadelphia, Pa.-N.J.	-1.0250 C 28	-2.5000 C 39	0.4500 C 27
Phoenix, Airz.	-.5917 A 8	-2.6333 D 49	1.4500 A 5
Pittsburgh, Pa.	-1.8667 E 65	-3.5333 E 65	-0.2000 E 60
Portland, Oreg.-Wash.	-.6500 A 11	-2.5000 C 40	1.2000 A 9
Providence-Pawtucket-Warwick, R.I.-Mass.	-.7667 B 14	-2.4333 C 34	0.9000 B 12
Richmond, Va.	-1.1333 D 41	-2.3667 B 27	0.1000 D 44
Rochester, N.Y.	-.7000 B 13	-2.0000 A 3	0.6000 B 18
Sacramento, Ca.	-.2000 A 1	-2.2000 B 11	1.8000 A 2
St. Louis, Mo.-Ill.	-1.5833 E 62	-2.7667 D 54	-0.4000 E 65
Salt Lake City, Utah	-1.0250 C 29	-2.5000 C 41	0.4500 C 26
San Antonio, Texas	-.8333 B 17	-1.8667 A 1	0.2000 D 39
San Bernadino-Riverside-Ontario, Ca.	.4750 A 5	-2.8000 D 56	1.8500 A 1
San Diego, Ca.	-.5333 A 6	-2.2667 B 19	1.2000 A 8
San Francisco-Oakland, Ca.	-.7000 B 12	-2.6000 C 45	1.2000 A 7
San Jose, Ca.	-.5333 A 7	-2.2667 B 20	1.2000 A 6
Seattle-Everett, Wa.	-.2667 A 2	-2.1333 A 7	1.6000 A 3
Spring-Chicopee-Holyoke, Mass.-Conn.	-.6167 A 10	-2.2333 B 15	1.0000 A 11
Syracuse, N.Y.	-1.1500 D 42	-2.2000 B 12	-0.1000 E 57
Tampa-St. Petersburg, Fla.	-1.0583 C 35	-2.4667 C 36	0.3500 C 34
Toledo, Ohio-Mich.	-1.1833 D 44	-2.2667 B 21	-0.1000 E 56
Washington, D.C.-Md.-Va.	.8333 B 16	-2.2667 B 22	0.6000 B 17
Youngstown-Warren, Ohio	-.9667 C 22	-2.5333 C 43	0.6000 B 16
Mean (X) =	-1.0342	-2.5015	-0.4331
Standard Deviation (s) =	0.3452	0.3577	0.5292

A = Outstanding (≤ x t s) •
B = Excellent (X + .28s ≤ B < x̄ + s)
C = Good (X - .28s < C < X + .28s)
D = Adequate (X̄ - s < D ≤ x̄ = .28s)
E = Substandard (≤ X - s)