SOCIOECONOMIC HEALTH OF ILLINOIS MUNICIPALITIES

HAROLD McCONNELL
Department of Geography,
Northern Illinois University, DeKalb, 60115

ABSTRACT. — A composite index of socioeconomic health was developed from a linear combination of standard scores on five fundamental attributes for the largest cities in Illinois. The cities are ranked on each of the attributes and on the composite index. Spatial and class variations are noted.

The term "socioeconomic health" is a composite expression of the various social and economic characteristics of a place. For purposes of comparison, a place with a high socioeconomic health level is in the aggregate beset with fewer pressing problems than one with a low level of socioeconomic health. The spatial variation of this phenomenon was first assessed quantitatively by Thompson *et al* (1962) in a factor analytic study of New York counties. Because of its obvious significance, this study might have provided the impetus for a number of such analyses in spite of certain statistical and procedural shortcomings. However, the Thompson paper remains the only example of its kind in the geographical literature. A variation of the method is presented here in a study of socioeconomic characteristics of urban places.

In brief, the study area is the state of Illinois and the observational units are its 41 largest municipalities in 1967 (Figure 1), although the analysis pertains to the early 1960's for reasons of data availability. All but five cities are located in SMSA counties. Principal components analysis was used to derive five fundamental socioeconomic attributes from a set of 31 population free indices. The attributes were quantified in order to classify the cities and used in linear combination in the construction of a synthetic measure of socioeconomic health. The index and a ranking of the cities thereon not only illuminates the spatial variation of level of socioeconomic health of Illinois' urban centers, but should prove useful to all disciplines concerned with the solution of contemporary urban problems, particularly in view of the impending availability of the 1970 Census of Population data.

NOTATION

Denote the following:

- Z—N x m matrix of standard scores
- R—m x m matrix of Pearson product moment correlations
- P—m x p matrix of correlations between standardized variables and principal components
- P′—m x p orthogonal rotation of P
- C—N x p matrix of standard scores on P′

N is the number of urban places (41), m is the number of socioeconomic indices (31), and p is the number of basic dimensions in R (5).

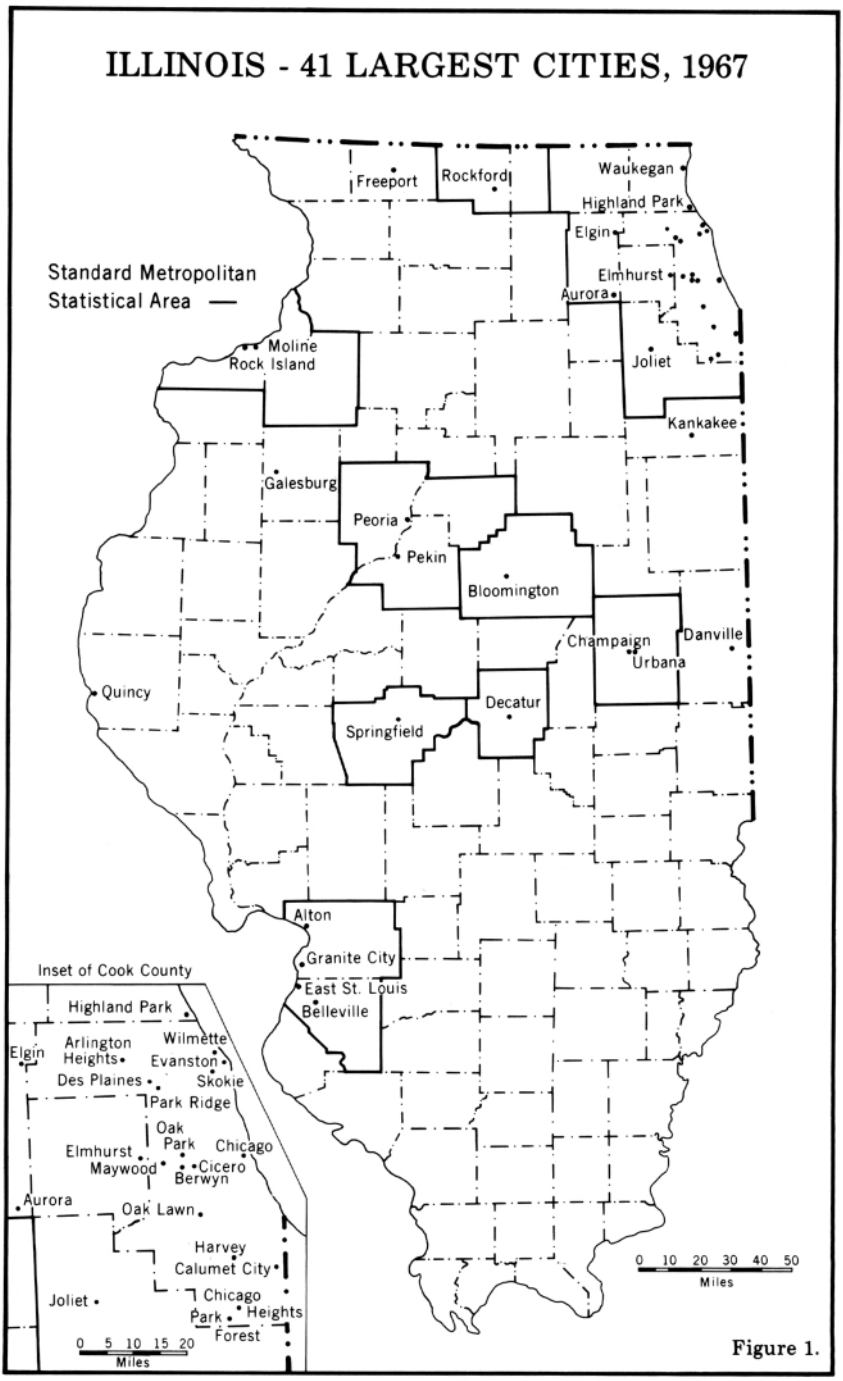

ILLINOIS - 41 LARGEST CITIES, 1967
Standard Metropolitan Statistical Area
Freeport
Rockford
Waukegan
Highland Park
Elgin
Elmhurst
Aurora
Moline
Rock Island
Joliet
Kankakee
Galesburg
Peoria
Pekin
Bloomington
Champaign
Urbana
Danville
Quincy
Decatur
Springfield
Alton
Granite City
East St. Louis
Belleville
0 10 20 30 40 50
Miles
Inset of Cook County
Highland Park
Elgin
Arlington Heights
Wilmette
Evanston
Skokie
Des Plaines
Park Ridge
Oak Park
Elmhurst
Chicago
Maywood
Cicero
Berwyn
Aurora
Oak Lawn
Harvey
Calumet City
Joliet
Chicago Heights
Park Forest
0 5 10 15 20
Miles

Figure 1.

PRINCIPAL COMPONENTS ANALYSIS

Each variable (Table 1) was transformed into its common logarithm and standardized. The correlations between the standard scores (R) were subjected to a principal components analysis, collapsing the original indices into mutually exclusive attributes: $(z_{x_1}, z_{x_2}, \ldots, z_{x_{31}})$ was transformed into a new set of orthogonal vectors or principal components $(P_1, P_2, \ldots, P_{31})$. Those five principal components whose

TABLE 1. Socioeconomic Indices.

Variable	Code	Description
1	PD	Population density per square mile (1960)
2	PG	Population growth (1960 population as percent of 1950 population)
3	PN	Percent nonwhite population (1960)
4	PF	Percent foreign born population (1960)
5	MA	Median age of population (1960)
6	PS	Percent of population 65 years of age and older (1960)
7	AP	Average number of persons per household (1960)
8	SH	Percent of population residing in same household as in 1955 (1960)
9	BDR	Birth/Death Ratio (1964)
10	FR	Fertility ratio (1960)
11	MS	Median school years completed for persons 25 years of age and older (1960)
12	PHS	Percent of population 25 and older completing high school or more (1960)
13	PM	Percent of non-agricultural workers employed in manufacturing (1960)
14	PRT	Percent of non-agricultural workers employed in retail and wholesale trade (1960)
15	PWC	Percent of non-agricultural workers employed in white collar occupations (1960)
16	MFI	Median family income (1960)
17	PFI	Percent of families having less than $3,000 income (1960)
18	PSD	Percent of dwelling units classified as sound with all plumbing facilities (1960)
19	PSF	Percent of population residing in single family dwelling units (1960)
20	POO	Percent of dwelling units occupied by owner (1960)
21	MVO	Median value of owner occupied dwelling in 000 dollars (1960)
22	MGR	Median gross monthly rent, renter occupied dwelling (1960)
23	AIM	Average income, manufacturing production employee (1963)
24	MP	Manufacturing productivity (1963)*
25	AIR	Average income, retail trade employee (1963)
26	PCW	Per capita sales, retail trade (1963)
27	AIW	Average income, wholesale trade employee (1963)
28	NSE	Number of service establishments per 1,000 population (1963)
29	PCT	Per capita real and personal property tax paid (1964-65)
30	PCG	Per capita government expenditures, excluding capital outlay (1964-65)
31	NGE	Number of full-time government employees per 1,000 population (1964-65)

* Value added by manufacturing divided by total number of manufacturing production employees.

Source: U. S. Bureau of Census (1967, Table 4). Some indices are in modified form and others were calculated from data in the above.

eigenvalues (λ_i) are two or larger (Table 2) are considered to be the basic dimensions in R or the fundamental socioeconomic attributes of Illinois' urban places. Their corresponding eigenvalues are 9.98, 5.49, 3.14, 2.89, and 2.11, respectively, indicative of their order of relative importance, and account for approximately 76 percent of the variance in R.

Mathematically, the eigenvalues are the latent roots in the m characteristic equations which set the determinant of R at zero:

$$\begin{vmatrix} 1-\lambda & r_{12} & \dots & r_{1m} \\ r_{21} & 1-\lambda & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & 1-\lambda \end{vmatrix} = 0 \qquad (1)$$

Given that p_{ij} is the correlation between the ith variable and jth principal component or the ith coefficient of the jth component, a series of equations of the following form is developed:

$$\begin{aligned} p^2_{11} + p^2_{21} + \dots + p^2_{m1} &= \lambda_1 \\ p^2_{12} + p^2_{22} + \dots + p^2_{m2} &= \lambda_2 \\ \dots\dots\dots\dots\dots\dots\dots\dots & \qquad (2) \\ p^2_{1m} + p^2_{2m} + \dots + p^2_{mm} &= \lambda_m \end{aligned}$$

The function of the first principal component is to resolve a maximum amount of variance in R; succeeding principal components resolve as much as possible the remaining variance. Thus, it is necessary to maximize λ_1 initially, and Lagrangian multipliers (see Harman, 1967, pp. 136-142; King, 1969, pp. 172-173) are used to obtain

$$\begin{bmatrix} 1-\lambda & r_{12} & \dots & r_{1m} \\ r_{21} & 1-\lambda & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & 1-\lambda \end{bmatrix} \begin{bmatrix} p_{11} \\ p_{21} \\ \cdot \\ p_{m1} \end{bmatrix} = 0 \qquad (3)$$

The first root is the eigenvalue corresponding to P_1 and the remaining roots are the largest roots of $P_2, P_3, \dots, P_m$, respectively. The coefficients ($p_{11}, p_{21}, \dots, p_{m1}$) of P_1 are obtained by scaling its eigenvector by λ_1:

$$p_{i1} = a_{i1} (\lambda_1)^{\frac{1}{2}} \qquad (4)$$

The coefficients of $P_2, P_3, \dots, P_m$ are obtained by similar operations on the residual correlation matrices ($R - PP^t$) until $p = m$, $\Sigma\lambda_i = m$, and $PP^t = R$.

Principal Socioeconomic Attributes

Labeling of the attributes was facilitated by rotating P to P′, using a varimax criterion (see Harman, 1967, pp. 304-313) in which P is rotated so as to maximize the variance between the principal components, subject to maintaining each variable's communality. This has the effect of increasing the absolute magnitude of "loadings" whose absolute values are initially high and minimizing those whose values are low.

Using the magnitudes and signs of the rotated coefficients (Table 2), the principal components were identified as : P_1 — socioeconomic achievement; P_2 — demographic dynamics; P_3 — unimportance of man-

TABLE 2. Summary of principal components analysis.

Attribute		P_1	P_2	P_3	P_4	P_5
Eigenvalue		9.98	5.49	3.14	2.89	2.11
Percent of total variance in R		32.2	17.7	10.1	9.3	6.8
$\lvert p'_{ij} \rvert \geq .30$		p'_{i1}	p'_{i2}	p'_{i3}	p'_{i4}	p'_{i5}
Variable	Code					
1	PD				−.81	
2	PG	.61	.60		.37	
3	PN	−.65			−.38	
4	PF	.60			−.59	
5	MA		−.92			
6	PS	−.45	−.80			
7	AP	.56	.66		.35	
8	SH		−.77	−.48		
9	BDR		.87			
10	FR		.81		.39	
11	MS	.69		.57		
12	PHS	.53	.36	.57		
13	PM			−.89		
14	PRT			.30		.46
15	PWC	.74		.59		
16	MFI	.94				
17	PFI	−.94				
18	PSD	.93				
19	PSF		.30		.86	
20	POO	.42			.84	
21	MVO	.92				
22	MGR	.94				
23	AIM			−.64		
24	MP				−.43	
25	AIR					
26	PCR					.73
27	AIW	.60			−.44	
28	NSE	−.60	−.45			.42
29	PCT					.49
30	PCG					.86
31	NGE					.79

ufacturing; P_4 — residential site availability; P_5 — commercial and governmental services. The socio-economic achievement component (P_1) is manifested by high positive correlations with indices of affluence, educational level of the population, and value of dwelling unit. P_2 is indicative of youthfulness of the population and the ability of a city to attract and maintain population as evidenced by population growth through both in-migration and natural increase. P_3 is indica-

tive of economic diversification, or specifically of a city's lack of dependence upon manufacturing as the major source of personal income for its residents. P_4 correlates positively with indices of single family housing, availability of which is ultimately dependent upon site availability and lack of competing and often noxious land uses. P_5 correlates positively with strength of the commercial and governmental services base, and implicitly with disposable income and ability (or willingness) to support local government, notwithstanding that Springfield is one of those cities under study.

Scores on Rotated Principal Components

The standardized logarithms of the original socioeconomic indices were condensed into orthogonal, standardized measures of the rotated attributes in order that classes of cities might be elicited with a minimum distance squared grouping algorithm (see Berry, 1961; Marble, 1967, pp. 23-34), using their component score vectors as image points in Euclidian space, and that their socioeconomic health be evaluated. Denote an N x p matrix of such scores by C:

$$C = ZR^{-1}P' \qquad (5)$$

Then, c_{ij} is the standardized magnitude of P'_{ij} at the ith urban place. Zero is of a higher order of magnitude than a negative number; e.g., a positive score on P'_1 is indicative of a high socioeconomic achievement level, whereas a negative score indicates lack of achievement. A positive score on P'_2 indicates a dynamic population, however a negative score is characteristic of either demographic inertia or a declining population because of out-migration. A positive score on P'_3 suggests that a city's economic base is attributable to the tertiary and quaternary sectors: a negative score suggests that a city has an essentially manufacturing based economic structure. Similar reasoning may be applied to both P'_4 and P'_5.

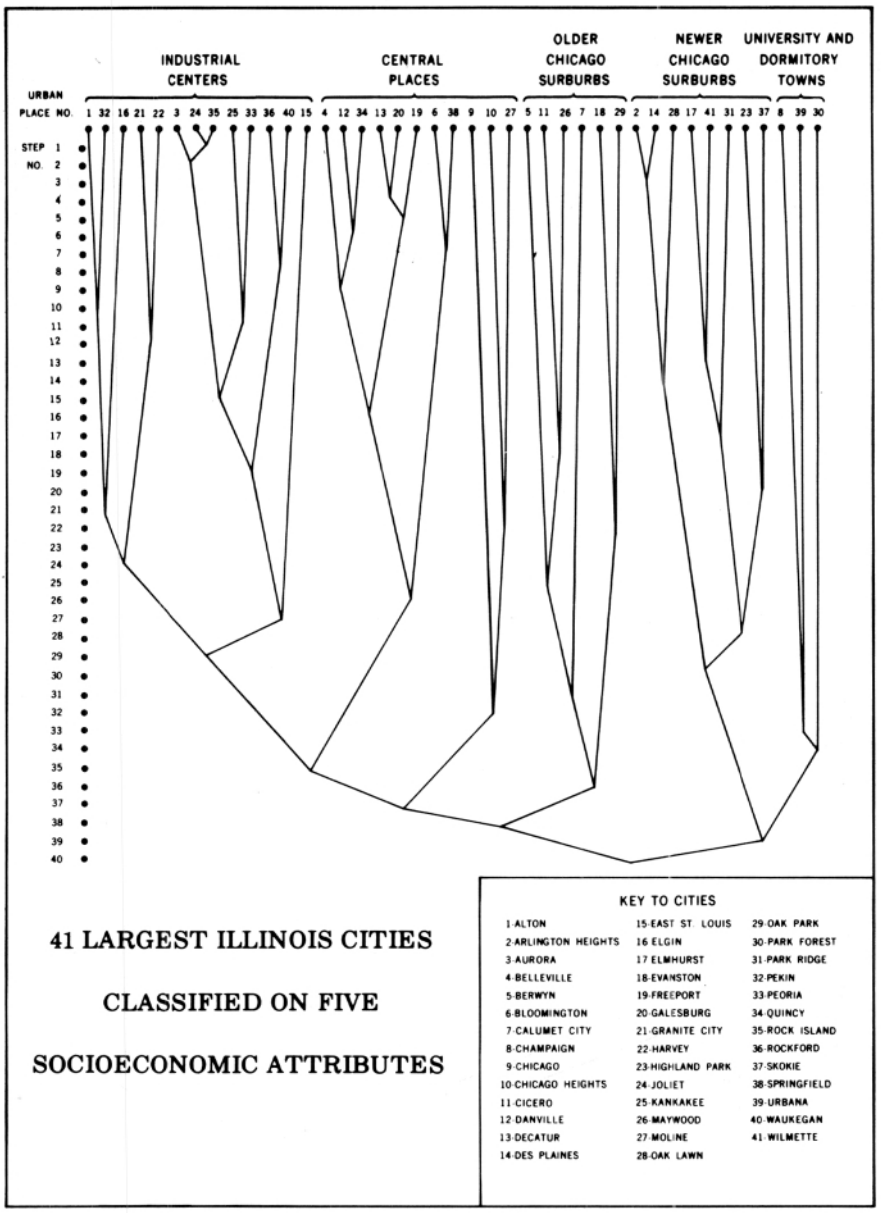
Classes of Urban Places

The grouping "tree" for the classification procedure is shown in Figure 2. Five classes (designated industrial centers, n = 13; central places, n = 11, serving and supported by smaller centers and the dispersed population; older Chicago SMSA suburbs, n = 6; newer Chicago suburbs, n = 8; and university and dormitory towns, n = 3) were elicited by the 36th iteration. Degrees of similarity between classes may be noted by perusing later combinations. Industrial centers are combined with the central places at step 37, followed by combination of this pair with the older Chicago suburbs at step 38. The newer suburbs are combined with the university-dormitory town group at step 39.

Rankings on Principal Components

The cities are ranked on the attributes in Table 3. Those cities ranking highest on socioeconomic achievement are clustered in the Chicago SMSA and include both established and newer suburbs of Chicago as defined in the foregoing. Nearly all downstate centers, including central places, industrial centers, and the college communities of Champaign and Urbana rank low on this dimension.

The newer Chicago satellites, Champaign-Urbana, and a number



of Chicago area and downstate industrial centers rank high on the demographic dynamics component, whereas the older, essentially impacted suburbs (e.g., Oak Park and Evanston) and those with a high degree of ethnic concentration (e.g., Berwyn, Cicero, and Highland Park) rank low, as do most downstate central places which are large-

TABLE 3. Largest Illinois cities ranked on socioeconomic attributes*.

P_1'—Socioeconomic Achievement	P_2'—Demographic Dynamics	P_3'—Unimportance Manufacturing	P_4'—Residential Site Availability	P_5'—Commercial and Governmental Services
1—Park Ridge	1—Park Forest	1—Urbana	1—Oak Park	1—Moline
Wilmette	Champaign	Champaign	Highland Park	Skokie
Skokie	Chicago Heights	Bloomington	Arlington Heights	Highland Park
Elmhurst	Oak Lawn	Evanston	Belleville	Chicago
5—Arlington Heights	5—Arlington Heights	5—Oak Park	5—Pekin	5—Champaign
Highland Park	E. St. Louis	Wilmette	Park Ridge	Chicago Heights
Park Forest	Skokie	Springfield	Danville	Springfield
Oak Park	Waukegan	Park Ridge	Des Plaines	Peoria
Berwyn	Harvey	Park Forest	Quincy	Evanston
10—Des Plaines	10—Des Plaines	10—Highland Park	10—Decatur	10—Bloomington
Evanston	Calumet City	Decatur	Alton	Wilmette
Oak Lawn	Granite City	Galesburg	Freeport	Rockford
Cicero	Urbana	Quincy	Galesburg	Waukegan
Maywood	Chicago	Skokie	15—Bloomington	15—Oak Park
15—Calumet City	15—Rockford	15—Freeport	Kankakee	Kankakee
Elgin	Maywood	Danville	Elmhurst	Danville
———	———	Arlington Heights	Skokie	Rock Island
Waukegan	Kankakee	Belleville	Granite City	Arlington Heights
Aurora	T19—Aurora	———	20—Joliet	20—Belleville
Rockford	T19—Alton	Kankakee	Rock Island	Des Plaines
20—Chicago	T19—Moline	20—Des Plaines	Elgin	———
Moline	21—Peoria	Rock Island	Springfield	Elmhurst
Harvey	Rock Island	Peoria	———	Joliet
Joliet	Joliet	Elmhurst	Aurora	Galesburg
Chicago Heights	Elmhurst	E. St. Louis	25—Rockford	25—Quincy
25—Granite City	25—Wilmette	25—Elgin	Moline	Aurora
Pekin	Decatur	Oak Lawn	Harvey	E. St. Louis
Rock Island	Peoria	Joliet	E. St. Louis	Maywood
Freeport	Galesburg	Pekin	Calumet City	Alton
Belvidere	Danville	Aurora		

TABLE 3. (Continued)

P_1'—Socioeconomic Achievement	P_2'—Demographic Dynamics	P_3'—Unimportance Manufacturing	P_4'—Residential Site Availability	P_5'—Commercial and Governmental Services
30—Urbana	30—Bloomington	30—Berwyn	30—Peoria	30—Harvey
Galesburg	Highland Park	Rockford	Waukegan	Park Ridge
Bloomington	T32.5—Evanston	Waukegan	Park Forest	Elgin
Alton	T32.5—Springfield	Moline	Chicago Heights	Cicero
Springfield	Freeport	Chicago	Oak Park	Freeport
35—Champaign	35—Park Ridge	35—Calumet City	35—Champaign	35—Pekin
Decatur	Belleville	Harvey	Berwyn	Decatur
Peoria	Quincy	Alton	Maywood	Granite City
Kankakee	Elgin	Maywood	Urbana	Berwyn
Quincy	Cicero	Chicago Heights	Cicero	Park Forest
40—Danville	40—Oak Park	40—Granite City	40—Evanston	40—Urbana
E. St. Louis	Berwyn	Cicero	Chicago	Calumet City

* Underline separates those cities with positive scores (above) from those with negative scores (below).

ly sources of young adult migrants to the more attractive Chicago SMSA.

Such traditionally industrially based centers as Cicero, Granite City, Chicago Heights, Chicago, and Moline rank high in terms of degree of dependence on manufacturing. Those cities in which manufacturing is comparatively unimportant as contrasted with the development of the higher order economic sectors include both new and established residential suburbs of Chicago, Champaign-Urbana, and downstate central places of which the outstanding example is Bloomington with its service industry base.

A high degree of residential site availability is characteristic of the newer, less impacted Chicago suburbs (e.g., Oak Lawn, Arlington Heights) as well as by most central places. The impacted suburbs, most industrial centers, Champaign-Urbana, and notably Chicago, rank low on this dimension.

The last attribute, commercial and governmental services, is more difficult to illuminate either spatially or by class. In any event, those cities which have a large proportion of the labor force employed by extra-local governmental agencies rank high (Springfield and Moline), as do many of the more affluent, established suburbs and some central places. At the other extreme, several of the newer suburban towns, particularly those without a high degree of commercial activity or exurban to the extent that governmental services have apparently had neither the time nor the need to develop despite an affluent population, rank low. The commercial-university dichotomy of Champaign-Urbana is particularly in evidence on this dimension.

Apart from any other relationship, the level of this component also appears to vary directly with size of the population and implementation of welfare programs.

Socioeconomic Health Index

A synthetic measure of socioeconomic health was constructed using a linear combination of the scores on the rotated principal components. Since socioeconomic achievement, a dynamic demographic condition, a diversified economic base, availability of land for single family residential construction, and a firm commercial - governmental services base may be considered as contributing to the socioeconomic viability of a city, the index might be written

$$HI_i = c_{i1} + c_{i2} + c_{i3} + c_{i4} + c_{i5} \quad (6)$$

where HI is the index score. However, the attributes do not have equal importance, and it is appropriate to scale the component scores, using the eigenvalues as coefficients of the linear combination. Thus, for this analysis,

$$HI_i = 9.98c_{i1} + 5.49c_{i2} + 2.14c_{i3} + 2.89c_{i4} + 2.11c_{i5} \quad (7)$$

The index scores and ranks are given in Table 4. The nine highest ranking urban place and thirteen of the highest ranking fourteen are located in the Chicago SMSA, again indicative of a remarkable contiguity effect. Moreover, their suburban nature is indicative of the flow of wealth and population from the inner city to the urban fringe in metropolitan Chicago. Of the Chicago area cities, only Berwyn and Cicero (close-in ethnic concentrations) from the suburbs and Chicago itself rank below the median for the cities

TABLE 4. Largest Illinois cities ranked on socioeconomic health index.

Rank	City	Health Index
1	Park Forest	28.73
2	Skokie	26.29
3	Arlington Heights	24.50
4	Wilmette	20.88
5	Highland Park	20.40
6	Oak Lawn	18.37
7	Park Ridge	18.02
8	Des Plaines	16.29
9	Elmhurst	14.93
10	Champaign	6.17
11	Evanston	3.22
12	Oak Park	1.96
13	Chicago Heights	.95
14	Waukegan	.67
15	Moline	—1.80
16	Calumet City	—2.01
17	Rockford	—2.20
18	Aurora	—2.64
19	Urbana	—2.97
20	Maywood	—2.98
21	Harvey	—4.14
22	Bloomington	—4.80
23	Joliet	—5.51
24	Rock Island	—6.07
25	Pekin	—6.17
26	Galesburg	—6.36
27	Elgin	—7.09
28	Springfield	—7.83
29	Belleville	—7.86
30	Berwyn	—7.96
31	Decatur	—8.29
32	Kankakee	—9.03
33.5	Freeport	—9.21
33.5	Granite City	—9.21
35	Peoria	—9.98
36	Alton	—11.42
37	Chicago	—11.45
38	Cicero	—12.03
39	Danville	—12.19
40	Quincy	—13.75
41	East St. Louis	—17.21

Mean Health Index by Class

Industrial Centers	—6.92
Central Places	—7.51
Older Chicago Suburbs	—3.30
Newer Chicago Suburbs	19.96
University and Dormitory Towns	12.62

under study. Conversely, all St. Louis area cities are below the median. Considered by class (the class means are given in Table 4), most high ranking urban places are suburban, and newer suburbs rank higher than older suburbs. The lowest ranking cities are either indus-

trial centers or central places. Of equal significance, there is also an apparent inverse relationship between the level of a city's socioeconomic health and distance from suburban Chicago.

Acknowledgments

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All phases of the principal components analysis were performed on the IBM System/360-40 digital computer formerly in use at Northern Illinois University, using BMD program BMDO3M (General Factor Analysis). The variables were converted to logarithms with BMD program BMD09S (Transgeneration). See Dixon (1967, pp. 169-184, 421-429) for detailed documentation of these routines. The classification procedure was performed on an IBM System/360-65 at the University of Iowa, Iowa City. See Marble (1967, pp. 22-34) for the program CONGROUP.

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