IMPACT MODELS OF HIGHWAY CONSTRUCTION ON URBAN NEIGHBORHOODS: SOME EMPIRICAL RESULTS*

Ben-chieh Liu, Midwest Research Institute

I. Introduction

In recent years, there has been an upsurge of interest in problems of evaluating the impacts on urban neighborhoods of transportation development in general, and highway construction in particular. The issues related to transportation system impact have become more compelling than those related simply to the balance between the supply and demand for transportation services. In other words, people are becoming more concerned about the so-called "concomitant outputs" such as the tangible and intangible effects of the system on society and the environment (e.g., air pollution, noise, land utilization, urban sprawl, community life style, neighborhood cohesion, etc.) than about the "performance outputs" such as changes in travel times, volumes, costs and other objectives of the transportation system [12].

How may the relationships between the amount and distribution of travel and the social, economic, political and environmental impacts of transportation facilities and systems be identified, measured and evaluated? What specific changes can be recommended so that the performance outputs can be maximized and the adverse concomitant outputs minimized? What research is needed that would contribute to efficient and optimal decisions regarding the provision of transportation facilities and services in both the short and long run in urban and rural areas? Answers to these questions are of critical importance because any intelligent transportation decision requires the inputs from not only transportation engineers, architects and planners, but also from a variety of others such as ecologists, economists, sociologists, etc. In any decision regarding freeway construction, the questions are whether the benefits derived from the particular freeway are greater than the costs associated with the construction of the freeway--whether direct or indirect, tangible or intangible, social or private benefits and costs--and how they are measured.

The primary objectives of this paper are to empirically evaluate and to test the relevance and usefulness of some predictive models and to develop an alternative quality of life indicator model for neighborhood impact assessment. Empirical results on neighborhood life quality changes attributable to highway construction are also derived and discussed.

II. Impact Models of Highway Construction: An Evaluation

Three predictive methods--mobility index, social feasibility model, and neighborhood social interaction index--have been recently developed for predicting the highway construction effect on the neighborhood, each one has its weakness and strength and on the whole, none of them can adequately reflect the construction impacts on urban neighborhood life quality.

The mobility indicator developed by the California Division of Highways [3], in the form of a numerical index, was made up of the percentage of: (1) owner-occupied houses; (2) single family residences; and (3) people in the same house over 5 years. The California approach was extended and tested further by a Texas A&M study of 152 neighborhoods and 47 control neighborhoods in Austin, Dallas, and Houston [8,9]. Mobility Index (MI) was computed simply as MI = 100 t/N, where t is number of persons who have resided in the same house for 5 years or more and N is total population in that census tract.

The mobility index is based upon the average time that residents in a neighborhood occupy a dwelling unit. This indicator does not by itself reveal either negative or positive neighborhood social values. High mobility so defined may increase community cohesion as well as lower housing property values. The effects depend in large part upon the nature of the neighborhood and the socioeconomic characteristics of the in- and out-migrants being studied. In addition, the fact that freeway construction through a neighborhood with a high mobility index may in fact increase the mobility of the neighborhood and the destrictive effect may very well be offset by its positive contribution to labor mobility. Furthermore, the disrupted neighborhood cohesion might not be due as much to the freeway, once constructed, as it is to the changes in the perception of neighborhood identity, street environment changes, residential mix, development characteristics, etc.

A Neighborhood Social Interaction Index (NSII) has been developed to show neighborhood behavior (neighboring, use of local facilities, and participation) and neighborhood perception (identification, commitment, and evaluation). The index can be estimated by using residential mobility (M), percent of residential land (R), and housing units per acre (HU). Mobility has been found to be so important that it alone can be used to provide rough estimates of social interaction changes that might be associated with highways.

Burkhardt [1,2] used the above mentioned three descriptors with the data for West Philadelphia, estimated the functional relationship between NSII and the descriptors and found the equation

$$NSII = 76.29 - 1.45\ M - 0.36\ R - 0.30\ HU$$

has very high coefficient of determination, $R^2 = 0.91$. In recognition of the external effect, Burkhardt finally added to his model another variable--intraneighborhood accessibility (A). The overall linear model measuring the change of social interaction looks as:

$$NSII = f(- M, - R, - HU, + A)$$

As Burkhardt pointed out, his NSII equation depends vitally upon the mobility variable which in essence is similar to the mobility index described previously. Our first criticism of the mobility index is also applicable to the NSII. However, the NSII may represent an improvement over the mobility index because the indicator has included both positive and negative factors, however subjective they may be, that the lower the NSII, the less disruptive neighborhood effect the highway construction has. Nevertheless, the weights of the four independent variables and their functional relationship with the dependent variable seem to be unduly dominated by the mobility index, and yet its negative impact on social interaction is not well specified and demonstrated, and far from being generally accepted.

The social feasibility model stresses the importance of pedestrian dependency and uses housing and population characteristics to discern and estimate this dependency. Several of the factors beyond walking were also used in estimating pedestrian dependency, e.g., ethnic groups and population age. Thus, pedestrian dependency as used in the social feasibility model to some extent serves as a surrogate for other neighborhood characteristics (such as neighboring). Pedestrian dependency can be calculated for a census tract, a city, or other area. It includes some combination of general pedestrian dependency, school pedestrian dependency, local shopping pedestrian dependency, and social institution pedestrian dependency.

Kaplan, Gan and Kahn [4] found that among the four activity patterns under study, school, shopping and social institutions are significant and important neighborhood-based activities. These activity patterns were therefore incorporated in their social feasibility analysis.

Although criticism can be levied against the social feasibility model (SFM) regarding the selection of variables, this model seems to be better than the mobility index and the neighborhood social interaction index models in that it takes into account a set of social variables concerning the physical environment, human behavior, and economic conditions. Moreover, a rank-order system was developed in the SFM to provide information for setting priorities and choices among alternatives. Its technique resembles the utility and preference ranking of the so-called "marginal analysis" in economics.

Our major criticism of SFM is related to its index structures. First, no theoretical foundation was given to support any of the formulas used. Second, there was no explanation as to why the three variables used should be weighted equally when constructing the index. Third, U.S. median income may be a better variable than city median income for the purpose of standardization. Fourth, would any other form of index construction be more meaningful than the product itself? Finally, why do neighborhoods with high proportions of children or the elderly be overemphasized and treated differently from others?

In short, all models described previously tend to fall short of theoretical foundation and methodological soundness in impact assessment in general and in social welfare evaluation in particular. Neither of these models possesses every basic characteristic essential to a social indicator utility and performance evaluation proposed by Liu [5,6].

The validity of the predictive models delineated in the preceding section were tested empirically by using 1960 and 1970 data from 24 study areas and 21 control areas selected from the four metropolitan areas having circumferential highways--Kansas City, Indianapolis, Omaha and St. Louis.

The principal criteria for selecting the study areas are: (1) the study area must have a new highway that opened up during the 1960's; (2) the census tract is used as a basic unit for impact assessment because it offers the most readily available socioeconomic data required in this study; (3) the selected census tract had a population between 2,500 and 10,000 in 1960; (4) within the population size range, at least one tract each is selected to represent the small, medium, and large neighborhood under study.

The principal criteria for selecting the control areas are the homogenity considerations in: (1) residential and commercial composition similar to the study area; (2) demographic characteristics by size of population similar to the study area; (3) socioeconomic characteristics by medium family income similar to the study area; (4) no freeway passing the area and also somewhat remote from the new highway being studied.

The mobility indicator approach implies that the mobility indicators should be greater in the study area in which a highway segments, than in a control area, i.e., the higher the mobility, the less the description of the highway construction would be. To test this hypothesis, the level of changes in the mobility index between the study and control areas are compared. The results obtained for the four selected metropolitan areas are neither consistent nor conclusive.

The social feasibility model was also tested by calculating the dependence rates for the four cities. According to this school, the higher pedestrian dependence is on walking, and hence, the more disruptive a highway would be. Therefore, the level of the change in the school pedestrian dependency rates in the study area should be smaller relative to those without a highway in the control area. However, empirical results show that differences in this rate are mostly inconsistent with the underlying hypothesis: the higher the rate, the more vulnerable the neighborhood is to disruption by a highway.

Similar inconsistent patterns emerged in the percentage changes of the local shopping facility pedestrian dependency and the social institutions' pedestrian dependency rates for the study areas in the selected four cities. For the local shopping facility pedestrian rate, of the six study areas in each city, three in Indianapolis, two in Kansas City, four in Omaha and three in St. Louis experienced "unexpected" difference in the rates relative to the control areas. For the social institutions' pedestrian dependency rate, "unexpected" changes occurred in four study areas in Indianapolis, five in Kansas City, four in Omaha and two in St. Louis.

These inconsistent patterns of the changes of both the component and composite pedestrian dependency rates for the four selected cities indicate that the social feasibility model is not an appropriate model for accurately predicting the impact of highway construction on a neighborhood. Stein [11] has recently provided detailed analysis and evaluation on these models.

III. A Neighborhood Quality of Life Production Model

The overall impact of highways should not only be studied for the benefits and costs to the highway users or even the neighborhood's residents, but also should be examined from the nonuser's point of view. In other words, the feasibility of a public investment should be analyzed from the viewpoint of the quality of life of all individuals affected by the investment, directly and indirectly. And if not all user and nonuser benefits and costs are to be studied, the impacts on the quality of life of the neighborhood residents before and after the investment should at least be investigated. A neighborhood impact model was thus recently designed to detect the changes in the quality of life of the neighborhoods in which new highways are constructed and used by the author [7].

For any individual, QOL expresses that set of "wants"--physical (PH) and psychological (PS)--when taken together, that makes the individual happy or satisfied. The concept of quality of life varies not only from person to person, but also from place to place and from time to time. Since most psychological inputs to our Quality of Life are not quantifiable, an empirical measure of the level of quality of life people enjoy must hold the psychological attributes constant, i.e.,

$$QOL_{jt} = f(PH_{jt} | PS_{jt})$$

The physical part of the neighborhood quality of life model was then described by Liu [1] as follows:

$$QOL^s_{jt} = g[EC(H, EX), ED(H, EX), SE(H, EX), MA(H, EX)]$$

$$QOL^c_{jt} = h[EC(EX), ED(EX), SE(EX), MA(EX)]$$

where H denotes highway construction and EX represents all exogenous changes other than highway; the subscripts j and t denote the jth neighborhood and time period t, and the superscripts s and c denote the study and control areas. The variables EC, ED, SE, and MA stand, respectively, the economic, education, social and environmental, and mobility and accessibility components.

The effect of highway construction and other concomitant exogenous changes on the neighborhood's quality of life can be described by:

$$dQOL^s = \frac{\partial g}{\partial EC}\left(\frac{\partial EC}{\partial H}dH + \frac{\partial EC}{\partial EX}dEX\right) + \frac{\partial g}{\partial ED}\left(\frac{\partial ED}{\partial H}dH + \frac{\partial ED}{\partial EX}dEX\right) + \frac{\partial g}{\partial SE}\left(\frac{\partial SE}{\partial H}H + \frac{\partial SE}{\partial EX}dEX\right) + \frac{\partial g}{\partial MA}\left(\frac{\partial MA}{\partial H}dH + \frac{\partial MA}{\partial EX}dEX\right)$$

Note that the signs of the partial derivatives of QOL with respect to the four components are all positive, while the signs of the partial derivatives of the four components with respect to H and EX are ambiguous a priori and should be determined via empirical estimation. In the case of control areas where no highway was built, the first term in each of the four brackets on the right-hand side of the least equation vanishes. Thus,

$$dQOL^c = \left(\frac{\partial g}{\partial EC}\frac{dEC}{dEX} + \frac{\partial g}{\partial ED}\frac{dED}{dEX} + \frac{\partial g}{\partial SE}\frac{dSE}{dEX} + \frac{\partial g}{\partial MA}\frac{dMA}{DEX}\right)dEX$$

The quantitative effects of highway construction on a neighborhood's physical quality of life may be additively measured and compared by comparing the magnitudes of $dQOL^s$ and $dQOL^c$. Specifically, if $dQOL^s$ is greater (or smaller) than $dQOL^c$, then highway construction is likely to be conductive (detrimental) to the physical quality of life of a neighborhood.

More than 30 factors were originally selected to represent the four quality of life components most affected by the highway construction, i.e., economic, education, social and environmental, and mobility and accessibility. The factors were selected on the basis of five criteria: commonality, simplicity, adaptability, neutrality, and utility [5]. However, due to data problems only 21 variables were practically employed in the model for final impact assessment. Appendix A presents the variables selected and the expected individual variable effect in the four objective components of our quality of life production model. Theoretically the four components are assumed to be independent of each other, and the quality of life level should be viewed strictly as a stock variable--it reflects the degree of human satisfaction at a particular point in time, given the quantity of quality inputs they possess. Practically, some of the assumptions have to be relaxed, e.g., the quality of life output is usually defined over a period of time and hence is a flow variable. Since the factors of both flow and stock variables are relevant for evaluating social well-being, the actual calculation of quality of life indicators involves variables characterized by either stock or flow attributes. Furthermore, the quality of life model developed on the individual basis is also personalized to describe the entire neighborhood on the assumption that individuals in the neighborhood are more or less homogeneous in socioeconomic background and utility considerations.

IV. Neighborhood Impact of Highway Construction: Some New Evidence

The model employed here is in an additive, linear form, and raw data on each individual variable were first standardized and transformed into the conventional "Z" scores such that the mean of the Z scores becomes "0" and its standard deviation becomes "1.0." The basic reason for this standardization is to eliminate the units of measurement among different variables so that they can be neutral and further operated depending only on the direction of those variables toward the explanation of the variations in the quality of life.

An equal weighting scheme was applied to the variables at the same level--subcategory, indicator category, and quality of life component--for simplification sake and future methodological departure as well. In order to avoid the influence of any variable taking on extreme value under such an equal weighting scheme, all "Z" scores were also converted into an ordinal point scale ranging from "1" to "5" based on their percentile distribution with the lowest 20.0 percentile being assigned "1," and the next "2," etc.

Data for all variables listed in Appendix A were collected for the 24 study and 21 control census tracts, earlier mentioned for 1960 and 1970 for the four SMSA's. The composite quality of life indicators were also computed according to the methodology above delineated. Although the changes in quality of life indicators from 1960 to 1970 in both study and control neighborhoods are important, and they do provide us the essential information on the general welfare in each of the neighborhoods over a period of 10 years, it should be noted that the associated changes per se convey no message as to the net effects of a highway on any neighborhood's general welfare. The net effects of a highway may only be reflected through the comparisons of the associated changes 1960 to 1970 between the study and the control neighborhoods. Specifically, if the associated changes for the period are greater (smaller) in the study areas than the counterparts in the control areas, one may conclude that highway construction does have some positive (negative) effects on neighborhood quality of life. In other words, the effects are judged by the ratio of quality of life indicators in the study areas to that in the control areas $(S/C)i$ over the 10-year period. The empirical results for the selected six pairs of neighborhoods in the four metropolitan areas for the quality of life component and overall quality of life indicators are shown in Table 1.

As the results in Table 1 show, when all six pairs of ratios were averaged, nearly all of the four quality of life components received a value greater than unity, except for the economic component in Omaha. This indicates that on the whole highway construction has brought about positive effects on neighborhood life quality on a regional basis, despite the fact that many neighborhood pairs of indicator ratios are less than unity. For example, highway construction had rather negative impacts on socioenvironmental considerations in Indianapolis since four of the six neighborhood pairs showed a ratio value smaller than 1.0 where study areas were compared to the control areas. Similarly, the unfavorable results were shown economically for Omaha and the negative impact was such that it even surfaced to appear at the metropolitan level as shown in the last column of Table 1. Nevertheless, the results, however tentative they are, may still lead one to conclude that, on the average, the construction of a highway has improved neighborhood quality of life about 3.0 percent in Indianapolis and St. Louis, 4.0 percent in Omaha, and 6.0 percent in Kansas City.

It should also be pointed out that the last column in Table 1 represents the major findings of this study. It is conceivable to have lower quality of life indicators in the study neighborhood areas than in the control areas because there are many factors other than highway construction which could affect neighborhood quality of life, i.e., the ratios of $(S/C)i$ could possibly be smaller than unity in some neighborhood areas even though our null hypothesis is that, in general, highway construction enriches neighborhood quality of life. However, the figures in the last column do point out the positive contribution of highway construction to neighborhood quality of life for the metropolitan area as a whole.

Given that there are differences in the metropolitan average comparison of study versus control areas, i.e., the ratios are greater than unity, one would question whether the differences are statistically significant. In other words, are the positive effects so identified for the study areas really different from those for the control areas, and are they statistically different at all from a no-effect nul hypothesis? A simplified Student "t" test suggested by Sandler [10] was performed on the basis of information shown in the last column of the table. The computed "A" statistics for the QOL component indicators is 0.173 and for the QOL indices, it is 0.273. Both of them are smaller than the corresponding critical values of 0.266 and 0.324 at the 5 percent significance level for 23 and 3 degrees of freedom, respectively. Thus, the null hypothesis that the mean QOL values for both control and study areas are equal is rejected. Consequently, the percentage gains in average QOL indicators shown in the last column of the tables mentioned are statistically sustained.

V. Concluding Remarks

Several predictive models of highway impacts on neighborhood, including the mobility index and the social feasibility models, were tested with the data collected from 24 study and 21 control census tracts in the four selected metropolitan areas between 1960 and 1970--Indianapolis, Kansas City, Omaha and St. Louis. Although the usefulness of these models was questioned theoretically, empirical problems of these models did also surface when they were applied to the selected areas for highway impact assessment. In view of the inconsistent and confusing results obtained, the empirical testings seemed to fail to lend support to the validity and the applicability of these predictive neighborhood impact models.

A transport-variant neighborhood quality of life production model was developed with the focus being on the effect of highway construction. The model essentially consists of two QOL production functions expressing the changes in the QOL, respectively, of the study and control areas, in response to the changes in the component indicators as a result of highway construction and other exogenous changes. The effect of highway construction on a neighborhood's quality of life is estimated by summing the effects of highway construction on the transport-related factors which form the basis for the computation of the four QOL component indicators, i.e., economic, education, social and environmental, and mobility and accessibility indicators, and then comparing them to the QOL indicators generated simultaneously for the control areas where no new highways were opened up during the study period. Specifically, the net impacts of highway are to be measured by differential rate of changes between the study areas and the control areas, i.e.,

$$(dQOL^{s}_{jt} \;/\; dQOL^{c}_{jt}).$$

The major findings of the recommended QOL models are that it is indicative, specific and capable of evaluating the construction impacts quantitatively for both purposes of ex-ante prediction and ex-post assessment. The opening-up of highways in the four metropolitan areas did improve the life quality of the affected neighborhoods in numerous accounts including enhanced economic vitality, greater mobility and better accessibility, higher educational attainment, and enriched socio-environmental conditions. For the overall life quality consisting of these four basic components, the results show that a gain of some 3.0 to 6.0 percentage points could be attributed to highway construction. Nevertheless, these are tentative and incomplete results not only because some important variables such as crime rates, property values, noise and air pollution were excluded due to unavailable data but also because the model only attempts to quantitatively measure the physical inputs to our quality of life while holding constant the psychological inputs. Furthermore, it is necessary that the utility of the QOL model and its technical approach be generalized and confirmed with more empirical applications.

REFERENCES

1. Burkhardt, E., "Impact of Highways on Urban Neighborhood, A Model of Social Change," Highway Research Record, No. 356, pp. 85-94 (1971).
2. Burkhardt, J., and J. Rothenberg, Changes in Neighborhood Social Interaction (Washington, D.C.: Federal Highway Administration, 1971.)
3. Hill, S. L., The Effect of Freeways on Neighborhoods (Sacramento: California Division of Highways, June 1967).
4. Kaplan, M., et al., "Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvement" (Springfield, VA: National Technical Information Company; 1972).
5. Liu, Ben-chieh, "The Utility of Quality of Life Indicators in Regional Public Decisionmaking," paper presented at the National Conference of the American Association of Public Administration, Washington, D.C., April 19-22, 1976.
6. Liu, Ben-chieh, "A Quality of Life Production Model for Project Impact Assessment," in K. Finsterbush and C. P. Wolf (eds.), Methodology of Social Impact Assessment (Pennsylvania: Dowden, Hutchinson and Ross, 1977).
7. Liu, Ben-chieh, "Models of Highway Construction Impact Assessment," Proceedings of Institute of Environmental Sciences (Mt. Prospect, ILL: The Institute of Environmental Sciences, 1977).
8. McLean, E. L. and W. G. Adkins, "Freeway Effects on Residential Mobility in Metropolitan Neighborhoods," in Highway Research Board, Highway Research Record, No. 356 (1971).

9. McLean, E. L., et al., "Further Investigation of the Mobility Index for use in Predictive Freeway Effects on Neighborhood Stability," Texas Transportation Institute, Texas A&M University College Station, Bulletin 41, June 1970.
10. Sandler, J., "A Test of the Significance of the Difference Between the Means of Correlated Measures, Based on a Simplification of Student's t," British Journal of Psychology, Vol. 46, pp. 225-226 (1955).
11. Stein, M., "Social Impact Assessment Technique and Thin Application to Transportation Decisions," Traffic Quarterly, pp. 297-316, April 1977.
12. Wachs, M., "Social, Economic and Environmental Impacts of Transportation, Systems Resource Paper," in Urban Travel Demand Forecasting, Special Report 143 (Highway Research Board, 1973).

TABLE 1

RATIOS OF QUALITY OF LIFE INDICATORS BETWEEN STUDY AND CONTROL AREAS, 1960-1970

SMSA and QOL Component	Neighborhood Pairs (S/C)1	(S/C)2	(S/C)3	(S/C)4	(S/C)5	(S/C)6	Metro. Av.
Indianapolis							
(EC)	1.06	1.27	1.02	0.72	1.05	1.13	1.04
(MA)	1.20	1.29	1.33	1.15	0.43	0.91	1.05
(Ed)	1.05	1.42	1.23	0.61	1.79	0.56	1.11
(SE)	0.87	0.88	1.79	0.65	0.95	1.47	1.10
Overall	1.02	1.21	1.31	0.78	0.88	0.98	1.03
Kansas							
(EC)	1.33	1.00	0.99	1.31	0.78	0.87	1.05
(MA)	2.66	2.66	0.86	1.05	1.00	0.48	1.45
(Ed)	0.67	1.19	1.57	0.61	0.99	1.08	1.02
(SE)	1.23	0.75	0.96	0.88	1.02	1.19	1.01
Overall	1.36	1.24	1.05	0.94	0.93	0.86	1.06
Omaha							
(EC)	0.65	0.92	1.15	1.05	0.85	1.25	0.98
(MA)	1.17	2.10	1.99	1.03	0.80	0.74	1.31
(Ed)	1.14	1.08	0.92	1.00	0.94	1.00	1.01
(SE)	0.49	1.04	1.16	1.42	1.13	1.32	1.09
Overall	0.87	1.14	1.24	1.10	0.92	1.05	1.04
St. Louis							
(EC)	0.54	1.31	1.04	0.96	1.01	1.19	1.01
(MA)	0.65	1.11	0.43	0.88	1.00	2.00	1.01
(Ed)	0.17	1.26	1.51	1.14	1.09	1.99	1.19
(SE)	1.00	1.44	0.96	0.91	0.94	1.01	1.04
Overall	0.52	1.27	0.91	0.96	1.03	1.49	1.03

SMSA stands for Standard Metropolitan Statistical Area--one or more contiguous counties with a central city having 50,000 or more people.

* The research underlying this paper was supported by a contract (DOT-FH-11-8788) from the Federal Highway Administration to Midwest Research Institute. The helpful assistance and comments of Floyd Thiel and Roger Mingo of FHwA, Eden Siu-hung Yu of Oklahoma University and Mary Kies and Barry Sanders of MRI are acknowledged. The views expressed in this paper are those of the author and he is solely responsible for any remaining shortcomings.

APPENDIX A

NEIGHBORHOOD LIFE QUALITY COMPONENTS AND FACTOR EFFECTS

Economic Component	Factor Effect
I. Individual Economic Well-Being	
A. Median family income	+
B. Wealth	
1. Percent of owner-occupied housing units	+
2. Percent of households with no automobiles available	-
3. Median value of owner-occupied single-family housing units	+
II. Community Economic Health	
A. Percent of families with income below poverty level	-
B. Percent of families with income below poverty level or greater than $15,000	-
C. Unemployment rate	-
x D. Land value	
1. Commercial and industrial	+
2. Undeveloped	+

Education Component	
I. Median School Years Completed by Persons 25 Years Old And Over	+
II. Percent of Persons 25 Years Old and Over Who Completed 4 Years of High School or More	+
III. Percent of Persons 25 Years Old and Over Who Completed 4 Years of College or More	+
IV. Percent of Population Ages 3 to 34 Enrolled in Schools	+
x V. Changes in the Elementary School Attendance Rate	+

Social and Environmental Component	
I. Individual Conditions	
A. Existing opportunity for self-support	
1. Labor force participation rate	+
2. Unemployment rate	-
B. Percent of workers working in their county of residence	+
II. Community Living Conditions	
A. Percent of families with income below poverty level	-
B. Percent of housing units lacking some or all plumbing facilities	-
C. Percent of occupied housing units with 1.01 or more persons per room	-
D. Percent of workers using public transportation	+
x E. Acres of parks and recreation areas per 1,000 population	+
x F. Crime rate	-
x G. Population density	-

Mobility and Accessibility Component	
I. Mobility	
A. Percent of persons who have resided in same house for 5 years	-
B. Percent of households with no automobiles available	-
C. Percent of time saved in traveling to city hall	+
x D. Housing segregation index	-
x II. Accessibility	
A. Number of retail establishments built since 1960 (per 1,000 population)	+
B. Number of gas stations built since 1960 (per 1,000 population)	+
C. Hospitals built since 1960 (per 1,000 population)	+
D. Schools built since 1960 (per 1,000 population)	+
E. Parks and recreational areas developed since 1960 (per 1,000 population)	+
F. New housing starts (per 1,000 population)	+
G. Property crime rates (per 1,000 population)	-
H. Traffic count in the busiest intersection in the tract	-

Factors and component marked with x were not included in the study due to data deficiency.