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Indicators of Environmental Issues for Urban Transportation Planning and Policy Making

by

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EXISTING TAXONOMIES for evaluating changes in urban transportation investment appear to be sensitive to short run and local considerations such as pollution and neighborhood disruption.[1] Fundamental difficulties arise, however, when regional and long range issues are cited as potential tradeoff considerations by planners and policymakers. For example, local citizens or other interest groups can more easily identify costs associated with construction of a specific project, yet find it more difficult to consider the long range benefits associated with regional improvements in transportation efficiency and productivity. Traditional approaches to describing and perhaps analyzing these types of benefits need to be improved so that displays of impacts are easily understood. Further refinements include the conversion of long range plans into incremental steps suitable for inclusion in these displays and the identification of "anticipatory indicators" which can be integrated into existing planning models to predict the relative magnitude of impacts and in turn help predict critical problem areas or bottlenecks. This paper attempts to define and illustrate the use of indicators which are based on data currently available in most long-range planning models. Displays of these indicators may be of use in community participation activities and to anticipate the general implications of alternative transportation investment strategies.

Indicators have become a popular technique for converting social statistics into a more meaningful and purposeful context and have been defined as a "nonmonetary measure of social performance or output"[2] or the ratio of actual status to desired status. Also, the relationships of indicators to impact factors seems more easily derived than the corresponding relationship between aggregation of indicators into accounts and the relationship of both indicators and accounts to planning models. Yet the arrangement of these indicators into a more orderly format or possibly a hierarchical structure may be essential to integration or utilization by planners. For example, economic planners utilize national income accounts to order selected economic indicators (obtained from an even broader set of economic data) into comprehensive analytical models which are then, at least in theory if not always in practice, are used in formulating or evaluating policy alternatives.[3] Transportation planners also have developed complex models which aggregate statistics such as travel volume and indicators such as accessibility and these models are utilized to forecast or project future transportation investment requirements.

The development of anticipatory indicators for transportation planning requires some redefinition of indicators particularly with respect to the measurement of impacts. Although impact analysis is historical and past-oriented, when researchers seek information to predict expected changes, impacts become a future-oriented data base. Anticipatory indicators thus are not the ratio of desired to actual status but the ratio of expected (whether desired or not) to projected status. This includes estimates of probable or actual changes expected and compares the extrapolation of trends assuming no change in status occurs. An illustration of the transition between measures of socioeconomic impacts and the anticipation of environmental changes resulting from transportation forecasts is provided by results derived from a recent research study.[4] For example, Table 1 gives data for Washington, D.C. which illustrates the end-product of a comprehensive assessment of the employment and demographic impacts of several alternative transportation investment requirements. The ratio of forecasted changes in population and employment under different alternatives with expected (e.g., Census forecasts) changes may be converted into anticipatory indicators.

The comparison of forecasts prepared by the Bureau of Economic Analysis[5] and Curtis C. Harris Associates[6] provides the opportunity to develop a simple example of anticipatory indicator. (See

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TABLE 1
ILLUSTRATIVE DISPLAY OF REGIONAL IMPACTS OF ALTERNATIVE TRANSPORTATION INVESTMENTS[1]

	Population (000)			Employment (000)			Income ($000,000)		
Alternatives[2]	1970	1990	1990-1970 Difference	1970	1990	1990-1970 Difference	1970	1990	1990-1970 Difference
1970 Interstate	3,090	4,777	1,687	1,452	2,360	908	13,090	32,160	19,070
Completed Interstate	3,090	4,810	1,720	1,452	2,376	924	13,090	32,415	19,325
Extended Primary	3,090	4,734	1,644	1,452	2,340	888	13,090	31,784	18,694
Economic Development	3,090	4,720	1,630	1,452	2,343	891	13,090	31,790	18,700
Urban	3,090	4,963	1,873	1,452	2,430	978	13,090	33,432	20,342

1 Estimates derived from data on Washington, D.C. Functional Economic Area, "Regional Economic Effects of Alternative Highway Systems," Curtis C. Harris Associates, Inc., for Federal Highway Administration, Washington, D.C., 1973.

2 The alternatives are defined in the above report. In this illustration the 1970 Interstate alternative assumes no additional investment was made in Interstate highways. The completed Interstate alternative assumes that no additional investment will be made subsequent to 1976. The remaining three alternatives assume expenditures of $455 million, $392 million, and $2,187 million in the construction 202, 386, or 129 freeway miles, respectively. (It is assumed that this investment will be constructed to Interstate design standards and costs are adjusted to real 1970 dollars.)

Table 2 which is based on data for the Washington, D.C. Functional Economic Area.) Since each transportation alternative was based on different regional but comparable national investment levels, the differential impact on one urban region may provide some interesting insights. The use of indicators as a display will also facilitate discussion by citizens and community leaders who wish to consider the impact of growth and the consequences of national transportation alternatives on urban population employment and income levels. Naturally, future levels of environmental pollution, energy requirements and public infrastructure needs all will depend on the relative magnitude and timing of urban growth. By developing sensitivity bands, planners can convert these expected changes into "early warning devices."[7]

The Curtis Harris Model: A Description

The Curtis Harris model is an operating interregional dynamic model that forecasts industry activity and other variables at the regional level. The model is subdivided into 99 industry, 69 equipment, 28 construction and 8 governmental sectors with data developed for 1966 for 173 functional economic areas (multicounty areas defined by the Bureau of Economic Analysis of the U.S. Department of Commerce). Forecasts are derived from recursive iteration of the linear equations describing each sector with regional adjustments so that national control totals are not exceeded. The national totals are based on 1985 I-O forecasts of Clopper Almon at the University of Maryland and are adjusted for changes in technology. Transporta-

TABLE 2
INDICATORS OF CHANGES IN POPULATION, EMPLOYMENT AND INCOME: WASHINGTON, D.C. FUNCTIONAL AREAS

	Bureau of Economic Analysis[1]	Anticipatory Impact Indicators[2] 1990 Alternatives				
	1990	I	II	III	IV	V
Population (000)	4,550	105	106	104	104	109
Employment (000)	1,960	120	121	119	119	124
Income ($000,000)	32,655	98	99	97	97	123

1 1972 OBERS Projections: Regional Economic Activity in the United States," Volume 2, U.S. Water Resources Council, Washington, D.C., September 1972.

2 Based on index of forecasts of Bureau of Economic Analysis and impact estimates derived from Harris Model (See Table 1).

tion investment is considered as a basic element in determining industry output through the use of "shadow prices" or marginal transport costs. These costs are defined as:

(4) $TQ^t_{ij}, TI^t_{ij} = f \quad (S^t_{ik}, D^t_{ik}, T^t_{ikh})$

where TQ^t_{ij} = transport cost of shipping a marginal unit of output from industry i out of region j in year t.

TI^t_{ij} = transport cost of obtaining a marginal unit of input from industry i into region j in year t.

S^t_{ik} = total supply of goods classified by industry i in year t for each region.

D^t_{ik} = total demand for good classified by industry i in year t for each region.

T^t_{ikh} = transport cost of shipping a unit of commodity i from region k to region j in year t.

with the following notation:

i = industry sectors

h, j, k = region or regions (1, . . . 173)

t = year

The marginal costs are computed using a linear programming algorithm which considers cost, speed and distance relationships between regional modal points and adjusts regional shares of output accordingly. Since the results of the model are forecasts of employment, income and population, they may be contrasted with standard forecasts which do not attempt to consider changes in transportation investment, infrastructure or accessibility. Furthermore, since the modal is recursive, tests of accuracy can be made comparing base year (1966) results with actual 1970 data. Some conceptual limitations which the utilization of this model has helped to overcome are that the model (1) defines urban areas in terms of functional economic areas which includes surrounding nonurban portions of regional economic base; (2) integrates transportation cost as factor in industrial location and (3) formulates forecasts based on impact of hypothetical investment alternatives.

Conclusion

Although indicators have been defined for various purposes, a systematic structure of environmental parameters which is related to a comprehensive transportation planning model has yet to be developed.[8] Developing anticipatory indicators which satisfy the needs of urban analysts and also are useful to decisionmakers is not a simple task.[9] However, developing a systematic procedure for identifying relevant variables for impact measurement and techniques for predicting these impacts is needed to anticipate problems. Transportation planning models and impact estimating tools such as the Harris multiregional forecasting model can be combined to alert officials and citizens of potential changes resulting from proposed or hypothetical investment decisions.

In this illustration, the Washington urban region defined as a functional economic area is expected to experience somewhat different rates of demographic and economic growth. Heavier levels of urban investment seem to attract or retain a greater proportion of growth for this particular region relative to other regions in the Nation. Should this additional investment occur and should this additional growth be unanticipated pressures or bottlenecks are more likely to occur. These pressures have strong implications for transportation environmental planners who seek to maintain stable utilization of resources and a preservation or improvement in environmental quality. Furthermore, the implications of these interregional shifts on the intraregional distribution of land uses and economic activity also may warrant attention. Thus, impact estimates may be one way for urban scholars or analysts to alert decision makers and the community of the consequences of decisions and to identify emerging pressures on environmental quality and resource requirements.

FOOTNOTES

[1] An example of general taxonomy for transportation investment is found in "Techniques for Considering Social, Economic, and Environmental Factors in Planning Transportation Systems," R. J. Bouchard, E. L. Lehr, M. J. Redding, and G. R. Thomas, Highway Research Board Record 410, 1972. A specific example of impact measurement is "Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements," Marshall Kaplan, Gans, and Kahn, for the Federal Highway Administration, 1972.

[2] "Social Indicators and Transportation," Mancur Olson, Highway Research Board, January 1973.

[3] For a comprehensive set of indicators see "The State of the Art: Social Systems Accounting," Bertram M. Gross in **Social Indicators**, ed. by Raymond A. Bauer, M.I.T. Press, Cambridge, 1966.

[4] The model is briefly described in "Long-Range Transportation Investment Planning: A Forecasting Approach for the Assessment of Alternative Highway Systems on Regional Development," C. Harris, S. Hille, C. Olson and M. Stein, Highway Research Board, 1973.

[5] "1972 OBERS Projections: Economic Activity in the United States," Volume 2, U.S. Water Resource Council, Washington, D.C. September 1972.

[6] "Evaluation of Regional Economic Effects of Alternative Highway Systems," Curtis C. Harris Associates, for the Federal Highway Administration, Washington, D.C., 1973.

[7] "An Early Warning System for Regional Planning," Thomas J. Ingmire and Tito Patri, **Journal of the American Institute of Planners**, November 1971.

[8] "Strategic Environmental Assessment System: A Study Design," MITRE Corporation for Environmental Protection Agency, December 1972, is an example of the beginning steps in the formulation of such a model.

[9] For a discussion of these problems see "The Problems and Pitfalls of Quantitative Methods in Urban Analysis," S. J. Bernstein, R. Ferber, and A. I. Bernstein, **Policy Sciences**, January 1973.