RELIABILITY ANALYSIS IN LAND USE-TRANSPORTATION PLANNING

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ABRIDGMENT

•IN THE preparation of land use-transportation system plans for any area, the input data involve several demographic and economic variables. For example, the future transportation demand of an area can be predicted on the basis of variables such as population, automobile ownership, and employment. Once the estimates of the input variables for a future design year are prepared, the aggregate information about the transportation demand for that design year can be obtained, and the required transportation facilities can be planned accordingly. However, the estimation of each of the causal variables is associated with uncertainties. These uncertainties are associated to a certain extent with the theory and technique used in predictive models that determine functional relations of the transportation demand with the causal variables. Similar statements can be made for most of the planning process, for land use-transportation planning entails a complex system acted on by numerous variables whose behavior is not well understood. In the area of planning methodology, the emphasis has been thus far on the development of approximate descriptions of unpredictable, socioeconomic phenomena. In planning practice, however, the use of any analysis is to aid the planner in making decisions. These decisions might involve the planning and design of public facilities such as transportation systems, sewerage and water supply systems, educational facilities, and recreational areas. Because of the uncertainties associated with the predictions of future year demands of such systems, the planner is faced with a difficult task of choosing the most accurate design level of demands. For example, if the design demand is expressed in terms of population figures and if the estimated future population figures are associated with a wide range of uncertainty, no amount of sophistication and refinement of the planning models will cause any substantial improvement in the probability of success of the facilities planned on the basis of these models.

For an efficient and effective planning process, a planner must make decisions as prudently as possible in the face of uncertainty. Before a particular element in plan design is included, the planner must search for the best design suited to the requirement involving the probability of success of the particular design element. In most situations the planner will obviously depend on his judgment as well as his experience. However, Bayesian decision statistics provide an excellent tool that can aid the planner in arriving at an optimal decision by combining his subjective judgment with objective information.

A planned system may be defined as one that is conceived, designed, and implemented to a specified level of reliability. A level of reliability is a measure of assurance that the system planned will serve its intended function successfully. Planning reliability can then be defined as a quantitative measure that the system planned will achieve successfully some presented level of performance.

In case of a transportation system plan, the component elements that constitute the plan design must be systematically examined in terms of their adequacy for the required demand during their intended life. For example, one aspect of the planning reliability of a transit system can be conceived as the measure of success in the prediction of ridership demand. Because the design level of ridership demand will determine the extent of the facilities to be provided, it is essential that the associated reliability in ridership prediction be carefully examined. The reliability of a highway system plan must also be examined in terms of its adequacy for the intended period of its design life.

Both the future ridership demand for a proposed transit system and the expected traffic volume on a planned highway network can only be estimated as a prediction. Because of the nature of the forecasting process in transportation system planning, the adequacy of a plan design can only be examined in the face of uncertainty. In other words, the evaluation of planning reliability is mostly concerned with the analysis of uncertainties involved with the forecasting process. With the application of a probability theory, a rational procedure can be developed to examine the extent of uncertainties involved in a particular demand forecast. Then, a decision theoretic approach can be adopted to determine the optimal level of a design parameter that is to be considered in systems planning.

As an example, the problem of forecasting the total population in the 7 counties of the southeastern Wisconsin region was considered. The analysis was performed in 2 steps. In the first step, the reliability of population projections obtained from the application of various techniques was tested. In the second step, estimates were prepared to evaluate the reliability of forecasting in a particular county. Subsequently, an optimal decision was made regarding the level of future design-year population for each county. The reliability of population projections was measured by the probability of predicted population figures falling within a given tolerance range. The reliability values for the different forecasting techniques considered ranged from 0.660 to 0.977 for a tolerance range of ± 5 percent. On the other hand, the reliability of forecasting for individual counties ranged from 0.868 to 0.969 for the same tolerance range. The upper bound of the optimal size of the sample to be tested was found to be 6 for given prior information and for assumed values of severity constant and unit sampling cost.

The example discussed here is a simple one; in reality, however, the planning and design decisions are associated with multiple variables, and a reliability analysis of the entire system should be made by optimizing the combined expected utility. Futhermore, more reliable cost data are required to develop associated utility functions. These data would include the cost items involved with the overdesigns and underdesigns of a planned system such as a transportation facility. However, these cost data can be developed with reasonable accuracy on the basis of the records maintained by the various public and private agencies.

The procedure outlined in the paper provides an opportunity for a planner to arrive at an optimum level of design-year population. Such a procedure can be an extremely useful tool in the overall land use-transportation planning process.

ACKNOWLEDGMENT

The work was in part sponsored by a research and training grant from the Urban Mass Transportation Administration.