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Abridgment

Estimation of Demand for Public Transportation

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This paper describes the mode-split model used by the Chicago Area Transportation Study (CATS). The model was formulated in 1972 and was first used in mid-1973 for the evaluation of the 1995 regional transportation plan (1, 2). Since then, the model has been used as an operational tool (3) and has been refined, recalibrated, and validated. The current operational version of the model is described in this paper.

CHARACTERISTICS OF THE MODEL AS A PLANNING TOOL

The mode-split model operates as an integral part of the CATS transportation planning process. The major products of the model are estimates of the number of trips by automobile and transit for each origin zone and trip purpose. If necessary, these estimates are further processed through the CATS planning models, including mode-specific trip-distribution models, to provide estimates of volumes on specific roads and transit lines. In other cases, where such detailed information is not required, estimated changes in transit and highway demand (in response to proposed policies) are directly applicable to the evaluation of those policies.

As with most mode-split models, the CATS model is sensitive to the levels of service provided by various transportation modes and to the socioeconomic attributes of travelers. However, the model is unique in its emphasis on the effect of access and egress service on the demand for transit. The model provides for an accurate description of the access and egress service, considering both the availability of various submodes and the variations in the level of service within zones due to spatial dispersion of trip ends. The model's capabilities make it possible to describe accurately a wide range of policies related to improvements in access and egress service and to estimate the effects of those policies on travel demand.

STRUCTURE AND OPERATION OF THE MODEL

The CATS mode-split model may be described as an application of Monte Carlo simulation principles to travel-demand analysis. It may also be described as an aggregation procedure, which facilitates the application of disaggregate mode-choice models (4, 5) by the use of aggregate data.

Straightforward applications of mode-choice models in planning are done in the following way. Data are collected on a sample of the population under analysis, including (for each trip) relevant socioeconomic characteristics, service attributes, and chosen mode. The sum of the individual choices, properly weighted, provides an unbiased estimate of the population's modal shares. The sample is used to estimate a mode-choice model. A policy to be analyzed is introduced into the sample as changes in the level of the attributes that are affected by the proposed policy, and the resulting changes in mode-choice probabilities are calculated. The changes in the sum of those probabilities are used as estimators of the expected changes in modal shares of the population.

Many successful applications along these lines have been documented (6-8); however, this method has a number of deficiencies that seriously limit its applicability. The most obvious are the cost and time required to collect the data and the inability to sample future populations. Other deficiencies include the difficulties of identifying the population affected by a given policy and of selecting an effective sample.

The CATS mode-split model uses the same conceptual approach; the difference is that a pseudosample rather than a real sample is used. The pseudosample is generated by sampling the frequency distribution of the attributes of the population under analysis. This approach permits full exploitation of the power of disaggregate models without a need for a real sample. The procedures for creating the sample are designed to operate not only within the limitations imposed by considerations of data availability and analysis costs but also with the provision of means for accurately describing a wide range of proposed policies.

Operation of the Model

The heart of the CATS mode-split model is a procedure that repeatedly generates individual samples and mode-

choice responses. Each sample corresponds to a single simulated traveler and his or her response to the modal alternatives available for a simulated trip. The attributes of the simulated trip maker and the characteristics of the trip are generated by a random Monte Carlo sampling process. The sequence of operations for generating a sample is described in Figure 1.

The following data are needed to generate the sample:

1. The person-trip table;
2. Matrices that show the zone-to-zone line-haul travel characteristics (such as times and costs for transit and highway);
3. Frequency distributions of household income by zones;
4. Frequency distributions by zone of the distance from a trip end to the nearest rail transit or commuter rail station, nearest bus stop, and nearest feeder bus service; and
5. Walking distance versus parking cost for the zones in the Chicago central business district (CBD) and parking access for the remainder of the region.

All those attributes that do not have high intrazonal variability (for example, line-haul travel times) are assigned to the trip directly from the zonal data. The attributes that do vary substantially within the zone are assigned by random sampling of the corresponding frequency distributions.

When the trip characteristics are estimated, the probability that the trip will use each of the available modes is estimated via a logistic mode-choice model. The process is then repeated a reasonable number of times for each zone (or interchange), and the estimated modal probabilities are accumulated. The resulting mode shares are used as estimators of the total population's mode split.

Description of Transit Service Attributes

A transit trip is subdivided into three portions: origin

Figure 1. CATS mode-split procedure.

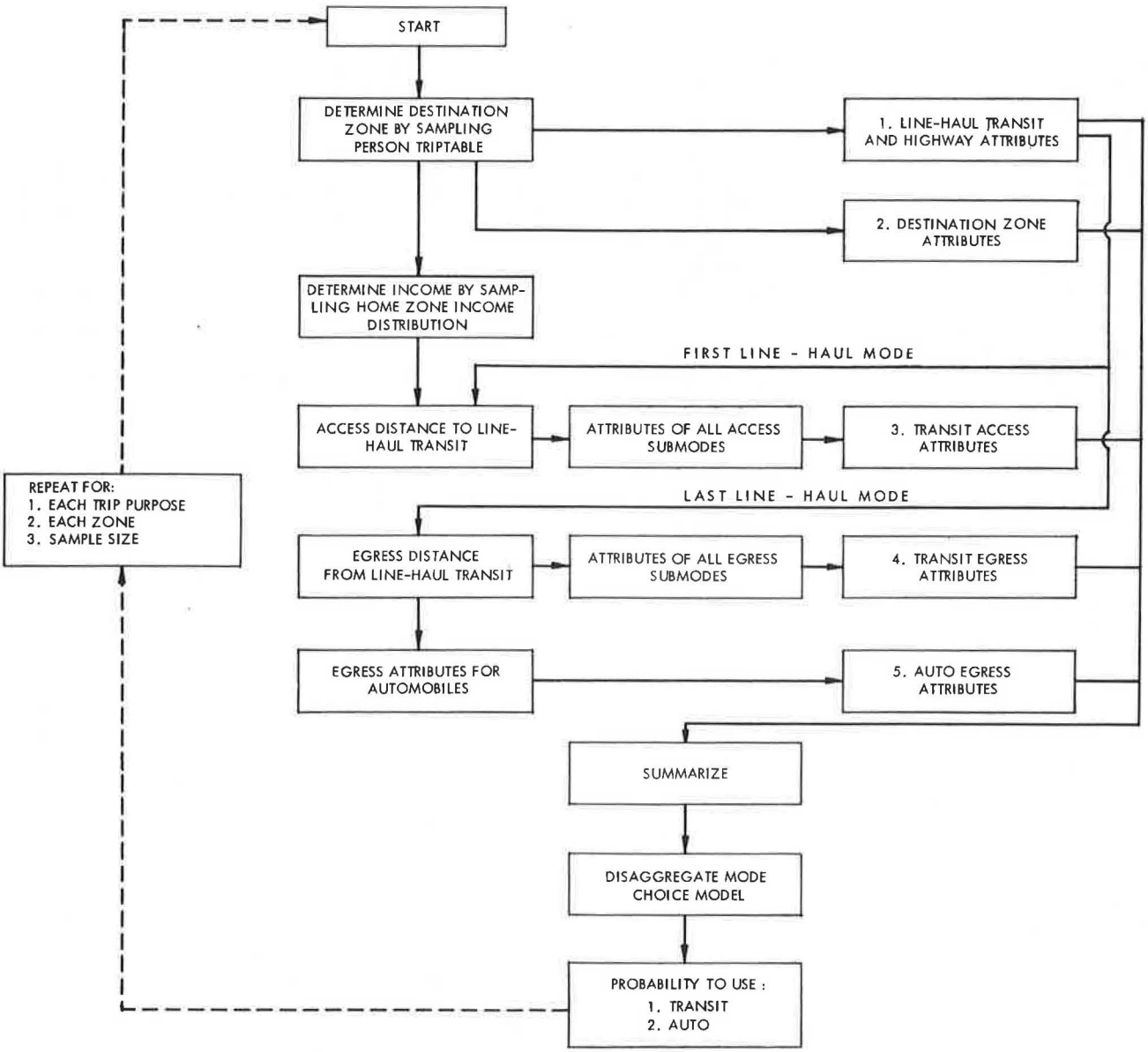

Table 1. Model variables and parameters.

	Work Trips								
	CBD			Non-CBD			Short Trips		
Coefficient	Final Value	Standard Error	T-Ratio	Final Value	Standard Error	T-Ratio	Final Value	Standard Error	T-Ratio
In-vehicle time	0.0276	0.0091	3.04	0.0024	0.0096	0.25	0.0077	0.0022	3.53
Cost	0.0121	0.0020	5.94	0.0152	0.0045	3.37	0.0187	0.0070	25.37
Excess time	0.0302	0.0098	3.08	0.0786	0.0214	3.68	0.0530	0.0030	17.49
Out-of-vehicle time	0.1139	0.0246	4.64	0.0616	0.0226	2.72	0.0070	0.0047	1.49
One-half first headway	0.0233	0.0160	1.46	0.0997	0.0341	2.92	0.0232	0.0040	5.84
Transit bias	-0.3594	0.1978	-1.82	0.3454	0.2065	1.67	1.4111	0.0382	36.97

Table 2. Mode-split: trips by transit.

		Work Trips					
		CBD		Non-CBD		Short Trips	
County	Population	Observed (%)	Predicted (%)	Observed (%)	Predicted (%)	Observed (%)	Predicted (%)
Cook	5 492 369	63.5	63.4	17.5	17.3	11.5	11.5
DuPage	491 882	69.9	60.8	2.1	4.7	1.0	2.0
Kane	251 005	72.3	66.5	0.9	2.5	0.5	0.9
Lake	382 638	68.5	61.0	1.1	2.7	0.6	0.9
McHenry	111 555	73.1	75.0	5.1	2.4	0.2	0.6
Will	249 498	52.1	55.4	0.0	1.3	0.0	0.4

approach (access), line-haul, and destination approach (egress). The attributes of the line-haul portion of the trip are determined from network analysis by using the Urban Transportation Planning System (UTPS) program UPATH (9). UPATH provides a description of the whole path from the origin to the destination, including access and egress. In order to separate the line-haul service characteristics, a special program strips the approach portions from the path. Approach is defined as walk and drive modes and, if the primary trip mode is rail, short bus legs. The program also records the first and last line-haul modes.

A special procedure is used to determine the approach impedance, given the line-haul modes. As part of the input, the program is provided with a description of the frequency distribution of the distance between the trip ends in each zone and the closest station. Separate distributions are provided for feeder bus, bus, rapid transit, and commuter rail. Those distributions can be estimated either mechanically (as a function of the service density) or manually.

The approach distance is determined by random sampling of the distribution corresponding to the first line-haul mode. In cases where feeder bus is a valid approach submode, the distance to the closest feeder stop is also determined by random sampling of the corresponding distribution. Given the approach distance, an estimate is made of the travel impedance by each of the available approach submodes. Submode impedances are estimated in terms of in-vehicle time, out-of-vehicle time, and cost. By using the parameters of the mode-choice equation, the total disutility by each of the submodes is computed, and the best submode is assigned to the trip. (Note that these data can be used readily to estimate submode split, if necessary.) The individual impedance measures of the selected approach submode are added to the line-haul measures for estimating the disutility for the whole trip and the mode-choice probabilities.

THE DISAGGREGATE MODE-CHOICE MODEL

The mode-choice model has been specified as a binary logit-choice model between automobile and transit:

$$P(t) = \exp(-\text{Transit disutility})/[\exp(-\text{Transit disutility}) + \exp(-\text{Automobile disutility})] \quad (1)$$

where P(t) = probability of selecting transit.

Table 1 lists the independent variables used for calculating the respective disutilities. Separate choice parameters have been specified for each of the following trip types:

1. Long residential trips (home-to-work trips) with CBD destination,
2. Long residential trips with non-CBD destination, and
3. Short trips (all trips other than home-to-work).

Model Estimation

A subsample of person trips from the 1970 home-interview data was used for model estimation. The home-interview data provided the origin zone, destination zone, and the mode used. Service attributes for the various modes were assigned by using engineering estimates based on the coded network and the mode-split model description of the access and egress service characteristics. One thousand observations were selected for each trip type. Table 1 summarizes the final estimated parameters by trip type.

Note that, in all three models, the parameters for in-vehicle time are rather low. This can be explained partly by the fact that the differences between automobile and transit in-vehicle travel times are generally not large. More important, this result of the calibration underscores the dominance of ease of access to transit as a determination of transit ridership.

Model Validation

The model was applied to the whole Chicago region by using 1970 data. The results were compared with the mode-split rates from the 1970 home-interview survey; a summary of the results appears in Table 2. Generally the model performed rather well in the developed parts of the region but tended to overestimate mode-split rates in the outlying areas. The reason for

this tendency to overestimate is still being investigated; preliminary observations indicate that more accurate determination of the frequency distribution of distance to bus in large zones that have scant transit service will correct this tendency of the model. Another possible reason is the lack of socioeconomic variables (e.g., income or automobile ownership) in this calibration. More detailed analysis of the model estimates for the developed portions of the region indicate satisfactory performance, even for small areas.

CONCLUSIONS

The paper describes a methodology for mode-split analysis that possesses a number of highly desirable attributes: (a) it is compatible with the conventional transportation planning process, (b) it permits the application of disaggregate mode-choice models, and (c) it permits a detailed description of the access and egress transit service and a realistic account of its effect on transit ridership. The method for describing the service is flexible enough to support analyses of nonstandard services, such as dial-a-ride.

The model is fully operational and has been proven applicable for analysis of large-scale regional problems as well as for small-scale, subregional projects, including transportation system management strategies. The resources required for data preparation and analysis are reasonable.

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Abridgment

Second Role of the Work Trip–Visiting Nonwork Destinations

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On a typical weekday in a major California urban area, about one-third of the households in which the head is employed visit one or more nonwork destinations as part of a trip to or from the workplace. Many transportation analysts find this number surprisingly high because conventional models of urban travel behavior make the assumption that the sole function of the work trip is to get the worker to and from the workplace. In fact, the analysis presented in this paper found that intermediate stops during trips to and from the workplace are an important means of visiting nonwork destinations and account for about 17 percent of nonwork destinations visited per household per weekday.

These figures are based on an analysis of home-interview origin-destination data collected in 1971 as part of the Fresno-Clovis area transportation study. An initial reaction to these numbers is to ask why Fresno is so at variance with the conventional wisdom. Fresno may be an unusual case; however, the use of complex patterns of travel found in Fresno is consistent with studies by Ginn and Horowitz of complex travel patterns in other cities (1, 2).

More likely, the conventional wisdom is no longer consistent with actual travel behavior. Cross-sectional evidence presented later in this paper implies that, if current demographic trends continue, the use of workplace-related trips to visit nonwork destinations will increase from the already substantial levels found in 1971. The conventional wisdom may be based on earlier data, collected when these types of trips were less important than they are now.

CHARACTERISTICS OF THE DATA

Before turning to the results of the analysis, briefly consider the strengths and weaknesses of the data on which they are based. The Fresno survey was used because the data were collected and organized in a disaggregated manner that permitted the analysis of complex travel patterns. These data reflect travel behavior before the oil emargo and subsequent increases in the price of gasoline. The data refer only to trips made by vehicle by persons age 5 and older. Thus, walking trips were excluded. Trips by vehicle include trips made by