Disaggregate Travel Demand Models for Special Context Planning: A Dissenting View

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This paper addresses the applicability of disaggregate travel demand models to the problems of special context planning. The paper investigates the nature of demand forecasting in special contexts and the degree to which disaggregate techniques meet prespecified modeling requirements. It is not based on a careful search of the literature for examples of the use of disaggregate travel demand models in special context planning. The findings are that disaggregate procedures have certain advantages over conventional techniques for special context planning but fall short of being true advances in demand modeling. This is because they are in reality not materially different in structure from conventional aggregate procedures, contain the same basic limitations as these methods, and do not extract the behavioral process underlying travel choices in special context planning any better than do conventional methods. The paper concludes that disaggregate modeling techniques appear to have their greatest value in structuring the analyst's approach to demand estimation and facilitating the calibration of demand models with small data bases. For these reasons they should continue to be explored as useful tools, but not to the exclusion of other research into the behavioral phenomena underlying special context planning.

Considerable discussion and interest have recently centered on the development of disaggregate behavioral travel demand models and their capabilities compared to conventional techniques. The stated advantages of these procedures are (a) a presumed closer approximation to individual choice processes because of the way in which individual data are treated in model construction and (b) more efficient use of data in model calibration. A central assumption made by the proponents of such models is that disaggregate techniques are by their nature more "behavioral" than conventional procedures and, therefore, are to be preferred in planning applications. Given the importance of such an assumption to the potential application of these tools, its validity should be examined in some detail.

A considerable number of disaggregate models have been developed to date and have mostly been applied to mode and route choice. In this context, disaggregate refers particularly to a group of models and procedures characterized by

1. Use of calibration techniques in which each individual observation is treated as a separate point rather than aggregated spatially, temporally, or demographically; and
2. Use of specific mathematical functional forms.

Of the numerous functional forms [general requirements are that the function be constrained over the 0 to 1 interval and be S-shaped (8)], the logistic curve (1, 2, 3, 4, 5, 7, 8, 9), the closely related discriminant function (5, 7, 10, 11, 12, 13, 14), and the probit function (5, 7, 8, 9, 15, 16, 17, 18) have been the most frequently used. In the logistic function, the probability that an individual will choose a given alternate from a binary set is described as

$$P_A = \frac{e^{G(x)}}{1 + e^{G(x)}}$$

where

P_A = probability of choosing alternative A, and
$G(x)$ = (assumed) linear combination of the attributes of A and other alternatives and also the characteristics of the chooser.

In the probit form, the model takes the shape of the cumulative normal curve

$$P_A = \frac{1}{2\pi} \int_{-\infty}^{G(x)} e^{-\frac{1}{2}u^2} du$$

Calibration has been achieved by least squares methods (1, 5, 20), but the usual procedure is maximum likelihood for probit functions and the discriminant criterion for the discriminant function. In most cases, the decision variables have been descriptors of system performance (e.g., travel time and cost) and socioeconomic descriptors of the traveler (e.g., income, automobiles owned, trip purpose). Some applications (5, 6) have used attitudinal variables in combination with socioeconomic descriptors. A number of multinomial extensions of these procedures have also been developed (2, 3, 4, 8).

That these models are disaggregate in their treatment of observations in calibration cannot be disputed; whether they are also behavioral is open to considerable question. In the context of travel demand analysis, to say that a model is behavioral means (to the authors) that

1. The model contains descriptors of those variables (system, socioeconomic, situational, and motivational) that actually cause the phenomenon being studied to occur (in other words, the model reflects a causal and not just a correlative process);
2. The structure of the model reflects the choice process of behaving units, both the chooser himself and other related decisions influencing his choice; and
3. Model calibration is based on a sample of observations for one behaving unit or a group of behaving units that are assumed (or, better, can be shown) to operate with a similar decision structure.

A central point in this paper is that the disaggregate techniques are not really that at all, but merely refined calibration methods that fall far short of a genuine advance in demand modeling methodology. To develop this point, we need to examine the nature of aggregation in demand models and clearly indicate just what a demand modeling process involves. From that we can specify whether these attributes of disaggregate procedures are in fact unique and whether they adequately meet the needs of special context planning.

AGGREGATION IN TRAVEL DEMAND MODELS

Types of Aggregation

In general, the purpose of travel demand modeling is to forecast—to predict within appropriate limits—the magnitude of travel demand (i.e., person trips or vehicle trips in an interval) expected to use a given alternative mode, route, or time period. This process involves 2 fundamental steps:

1. The construction of a model or forecasting device from a sample of observations of behaving units and the variables influencing them and

2. The application of the model to a (generally) larger set of behaving units to yield an estimate of probable behavior.

In the first step, the forecasting mechanism is developed by describing the characteristics of the behaving unit, the alternatives relevant to the choice, and the nature of the function relating choice to these descriptors. The parameters of the model are then developed empirically from the data sample through a process called calibration; they are interpreted as "best fit" coefficients rather than as representing the importance of the descriptors in any single individual's choice process. The key assumption of such a process, when data are obtained from a cross-sectional sample of observations, is that the observations grouped together for calibration all share similar decision processes (or, at least, processes similar enough for modeling purposes).

In the second step, the numerical values of the variables in the model are assumed at constant, revised, or forecast levels. Model coefficients are generally assumed to be constant, as are the model's functional form and the structural relations among variables. The forecast (i.e., the number of units projected to behave or be affected in a certain manner) is developed by applying the model with forecast variables to a large aggregate group of units, again assumed to be homogeneous with respect to the applicability of the model. This aggregate group itself may be forecast as well. In this step a crucial assumption is that the cross-sectional relation expressed by the model will hold over time. Up to this point we have merely described this process in its general form and have said nothing specific about the form of the model, its variables, or method of calibration. In transportation planning practice, 2 fundamentally different forms of aggregation are generally introduced into this process:

1. Aggregation of individual observations, spatially (e.g., zone or tract), temporally (e.g., peak hour or day), demographically (e.g., income level, trip purpose); and
2. Aggregation of information within each observation, as with travel time (5-minute travel time increments), income class codes, or components of trip travel segments.

At the analyst's discretion, each form of aggregation can also occur prior to or after calibration of the model, often both. Thus, we have 4 separate types of aggregation to contend with in building demand models:

1. Aggregation of observations, precalibration;
2. Aggregation of observations, postcalibration;
3. Aggregation of information, precalibration; and
4. Aggregation of information, postcalibration.

We are now ready to draw the distinction between disaggregate travel demand models and conventional procedures in common use today. In conventional demand models, observations are aggregated spatially, temporally, or demographically prior to calibration of the model, which is fitted to aggregate estimates such as work trip rates per zone. In a forecasting mode, the model is applied to an aggregate number of similar (again spatially, temporally, or demographically defined) units to yield an estimate of activity or behavior.

In addition, information is also aggregated within each individual observation in the process of data collection. Data on items such as income, age, and occupations are all coded to finite levels; travel times between zone pairs are measured from zone centroids; trip segments are sometimes aggregated into in-vehicle and out-of-vehicle components. In each such case, some detail concerning the nature of the individual trip record and the traveler is lost. Similar losses occur when variables similarly aggregated are used in the subsequent application of the model to a group of behaving units to yield the forecast.

In disaggregate demand models, on the other hand, data are not aggregated over observations prior to calibration. Each separate observation is treated as a unique point; calibration consists of estimating the parameters of the model from these separate points.

However, there the difference ends. The use of disaggregate models, once calibrated, is similar to that of aggregate models: The model is also applied to an aggregate (assumed homogeneous with respect to the behavioral process) set of units to yield the forecast. Information may also be aggregated within each observation, as with conventional procedures, in model development and application. In other words, currently constructed disaggregate travel demand models differ from aggregate demand models only in the first form of aggregation: Observations are not aggregated prior to model calibration. The terms aggregate and disaggregate, then, apply only to the treatment of observation prior to calibration; other aspects of aggregation are not included in the dichotomy.

Our main point in the above discussion is that disaggregate travel demand forecasting techniques differ from conventional methods in only 2 basic ways:

1. Treatment of individual observations in model calibration and the use of associated calibration techniques (maximum likelihood, discriminant criterion); and
2. Use of specific mathematical functional forms [even this distinction can easily be lost, as Stopher (1) demonstrates].

On the other hand, these procedures have in common with conventional techniques a number of characteristics:

1. Aggregation of information within observations before calibration;
2. Use of similar variables as descriptors of the behaving unit and the characteristics of alternatives (these variables have traditionally consisted of system performance descriptors, as opposed to the quality of service, and socioeconomic descriptors of the trip, person, and household, as opposed to descriptors of the decision-making process within households);
3. Combination of these variables into similar decision functions, usually expressed as a simple linear combination of attributes;
4. Aggregation of behaving units spatially, temporally, or demographically or all of these for application of the model in forecasting;
5. Development of basically correlative relations, as opposed to causal relations, between observed behavior and independent variables; and
6. Model development from basically similar data bases consisting of individual trip records merged with selected system descriptors.

The differences highlighted above are essentially mechanical in nature and pertain to the method of calibration and functional form of the model. The similarities are essentially structural in nature and pertain to the philosophy of travel demand forecasting. For this reason, we see little fundamental difference between aggregate and disaggregate demand forecasting techniques now employed and no difference suggesting a significant advance in demand modeling capability or in understanding travel behavior.

Are Disaggregate Techniques Really Different?

The above argument suggests that the claim that disaggregate models are by their nature more representative of individual decisions than are aggregate models seems open to considerable question. Disaggregate models are simply calibrated in a different manner—often to specific functional forms, often by the use of the same data in a different way. One may easily construct both aggregate and disaggregate models from the same data base and use the same basic functional form in curve fitting. The fact that one procedure uses individual observations to construct the model and the other uses aggregations of observations does not necessarily make the former more representative of individual behavior than the latter. Both procedures, after all, result in just one model describing the behavior of all individuals in the sample. Both methods of demand forecasting develop basically correlative relations between observed travel behavior (i.e., choices) and sets of system performance (e.g., travel time and cost) and socioeconomic (e.g., income, automobile ownership, trip purpose) variables. Both methods have operated on similar data bases, consisting of individual trip records merged with system characteristics, measured in perceptual or engineering terms. Both methods have generally assumed the choice criterion G(x) to be some combination of socioeconomic and system variables, the coefficient of each variable representing its relative statistical strength. And both methods are traditionally applied to aggregate groups of travelers, who are assumed to be homogeneous with respect to their choice processes, in forecasting demand in a planning context.

We need to begin immediately to separate the idea of disaggregate from that of behavioral. The two are not interchangeable; it does not follow that disaggregate models are behavioral or that aggregate models are not. A critical review of the structure of both disaggregate and conventional demand models constructed to date (and we include here market-share Luce models, abstract mode models, and economic demand models) suggests that (a) virtually all of these models are equally behavioral because of their structural similarities and (b) all of these models are equally inadequate extractors of the behavioral processes causing travel-related choices. Clearly, we have few, if any, examples of behavioral models developed to date for transport planning, disaggregate or otherwise. In addition, to date disaggregate techniques have been carried into forecasting (as opposed to a calibration medium) only rarely (20).

DISAGGREGATE TECHNIQUES IN SPECIAL CONTEXT PLANNING

If disaggregate techniques are not structurally different from conventional procedures, what, then, is their applicability to special context planning? Do their characteristics facilitate or restrict special context planning?

Special Contexts

Transportation planning encompasses a number of special problems that are not easily treated under general urban systems and corridor planning methodologies, both administrative and technical. These include the following.

1. Subarea and subcorridor contexts characterized as point locations in urban space. Examples are industrial parks and universities, urban renewal and development sites, CBDs, and neighborhoods. Transportation problems related to such areas can be described as (a) developmental activities that impact the surrounding transportation system (e.g., a proposed shopping center overloads a local street system), (b) changes in nearby transportation service or travel demand or both generated elsewhere that impact the site (e.g., a new expressway overloads streets of a residential area), and (c) provision of transportation services to particular client groups at the site.
2. Point-to-point and corridor-level contexts characterized by specific origin-destination flows. Examples are suburban-CBD commuter movements and CBD-airport flows. Transportation issues generally involve (a) provision of service to particular client groups (commuters, shoppers) or (b) unique activity site-residential site flows (from a Model Cities area to jobsites).
3. Areawide context characterized by regionwide impacts of service. Examples include (a) certain new technology applications such as PRT or dial-a-bus and (b) special service provision to geographically dispersed clients, such as the handicapped or elderly.
4. Options focusing on demand changes, such as staggered work hours, pricing and tolls, and automobile-free zones.

To the extent that planning in such situations requires special forecasting and evaluation techniques, we treat them below as special planning contexts, recognizing that the line between that planning and broader systems and corridor planning is often blurred.

Planning for special contexts is an important aspect of transportation planning and is receiving increasing emphasis in transportation analysis. In long-range urban transportation planning, problems have been traditionally addressed at the system scale. Analysis at this level involves the structuring and analysis of integrated systems plans for urban areas. Emphasis in evaluation has been on user and nonuser benefits and costs and the probable impacts of proposed facilities on the social, economic, and physical environment. System planning has often been approached (in practice) as a sequence of generalized corridor or sector plans, in which urban areas are broken up into sectors and each is studied separately. Some 250 long-range transportation planning efforts are now under way in nearly all major urban areas. Most of these have published a long-range plan and are moving into reanalysis and reevaluation of their initial assumptions and forecasts. As transportation planning evolves into the continuing phase, increasing emphasis is being placed on smaller scale planning at the corridor and project levels and on special context planning. But the nature of special context planning differs significantly from corridor and system planning in several respects.

1. Scale—Special problems often encompass 1 corridor, 1 point-to-point movement, or limited and fairly well-defined spatial areas.
2. Homogeneity—In some special problems (e.g., universities, CBDs) the population of interest is relatively more homogeneous than the urban population at large, particularly with respect to socioeconomic characteristics. There is little evidence, however, that such homogeneity of characteristics implies a similar homogeneity of the behavioral process that members of this group use in making transport choices (19).
3. Relevant variables—Special context problems often deal with behavioral processes that are quite different from those of larger contexts and that have different influencing variables. An example is the provision of transit service to the elderly.
4. Nature of improvements—Transportation proposals in special contexts often relate to improvements in service, are generally short-range in nature, and usually involve little capital construction or other massive investments. Transport improvements are often qualitative and bear on the comfort, convenience, and reliability of the service provided to the client group rather than on its performance characteristics.
5. Impact—Studies at this scale tend to focus on the impacts of the transportation proposals on client groups as opposed to the estimation of total travel demand. The definition and delineation of the client group itself are, of course, components of this process.

These differences suggest that many of the planning tools (particularly demand forecasting and evaluation) developed for system planning are not adequate for special context planning. It remains to be demonstrated, however, whether disaggregate procedures are any better.

We are now in a position to compare conventional and disaggregate techniques with reference to appropriate criteria for demand modeling in special context planning.

Planning Horizon

Most special context studies have a planning horizon of less than 10 years (new technologies planning is perhaps a notable exception), and thus long-range forecasts of demand are not warranted. To some extent, extensive analysis of transportation and land use feedbacks is unwarranted; travel demand modeling can often be limited to route, mode, and destination choices, unless accessibility is expected to substantially increase.

Both aggregate and disaggregate techniques can easily be developed for component models (e.g., modal split) without the necessity to include completed feedbacks. Most applications of disaggregate models to date have dealt with problems of calibration and have not been extended into a planning context. Both short- and long-range forecasts can be made with these procedures, but their use seems to be more appropriate in short-term forecasting because of the small scale of typical applications. Thus, disaggregate procedures appear to be superior on this criterion.

Extraction of Behavior

Ideally, the design of demand models should be based on the relation thought to exist between traveler behavior and socioeconomic and service variables. Obviously those variables most relevant to the choice should be accounted for. The analyst should resist the temptation to opt for a model based only on easily measured performance variables when it is apparent that significant qualitative factors also influence the choice process. This is particularly true in special contexts where behavioral processes and the variables influencing them are likely to be very different from those of the general population.

Although aggregate techniques have traditionally not been particularly behavioral in nature, they can be made so by the inclusion of relevant variables and more faithful representation of individual choice processes. Consider the problem of forecasting demand for reduced fares for the elderly. In studying such a problem, we should not be concerned as much whether we use an aggregate or a disaggregate procedure as whether we extract and adequately measure those parameters, such as cost, availability of service, special routings to appropriate destinations, factors in boarding and alighting from the vehicle, and time of day, that influence the clients' behavior. Such variables are not well represented in any current or proposed models, disaggregate or otherwise, in spite of the fact that survey research has shown them to be important determinants of behavior.

Method of Forecasting Demand

The nature of the demand forecast itself is different in many special contexts. In systems planning we are concerned with total demand, as influenced by general system and activity parameters; in special contexts we are concerned more with components of demand for subgroups and the sensitivity of this demand to changes in various system parameters, both performance and qualitative.

The primary advantage of disaggregate techniques here is that their use of certain functional forms facilitates computation of elasticities. Certain aggregate models (e.g., abstract mode formulations) also have this property. But this characteristic is wasted if the model does not contain those variables relevant to the choice. Considerable study, for instance, has been put into the estimation by the use of disaggregate models of cost and time elasticities; if this work were extended to other variables for special contexts, the application of disaggregate procedures in such contexts could easily be demonstrated.

The accuracy of disaggregate models compared to conventional techniques is unknown. Some limited evidence (mainly the experience of model builders) suggests that disaggregated models can be better calibrated to an existing data base than a conventional model can, sample size and heterogeneity being equal. How much of this advantage is subsequently lost in external application or in the use of disaggregate models in model chains is not known. Too little is now known of the magnitude of relative error propagated through travel demand models, either aggregate or disaggregate. Nevertheless, it seems clear that the content of variables used in these models will have a greater influence on their accuracy than the level of aggregation or its place in the modeling process.

Data Base

Ideally, one should be able to develop demand models from as small a data base as possible for efficiency in data collection. As much as is feasible, the method should represent or approximate the choice process of travel decision-making units (household or persons) rather than aggregate groups of units. The method must, of course, be applicable to larger population groups to yield the forecast.

Clearly, no one data collection method or procedure is applicable to the problems of all special problems. The particular context and its relevant dimensions (space, time, socioeconomic) should determine the nature of the data, the amount, and the level of aggregation. In general, special context planning appears to require fewer individual observations for analysis than does urban area systems planning. However, the detail of information obtained in each interview is typically greater than when data sets are intended for general system planning. Additional information often obtained includes traveler perceptions of the attributes of alternative modes, routes, or destinations, reasons for the choices, opinions toward proposed transportation improvements, and willingness to pay for them. Data for sampling special contexts are typically at the household or person level. For some contexts, a sampling "universe" is available for the particular client group (e.g., business in the CBD, university students); in other contexts (e.g., the elderly or handicapped), universe definition may be a serious problem.

A clear advantage of disaggregate models is the small sample sizes necessary to calibrate them. Evidence to date shows that they can be easily calibrated with samples of 500 to 1,000 records (5, 6, 20, 21), at least in the binary cases. Further, the use of specific functional forms permits the analyst to better extract the mathematical properties of the model (such as elasticity and behavior at the limits) and apply these to the particular context. This characteristic is applicable, of course, to aggregate models fitted to the same functional forms.

Operation

Demand models should, if possible, possess certain attributes to facilitate their use in practice. Among these are internal consistency and sensible structure, ease of calibration, strong theoretical base, efficiency, and parsimony with respect to input and output. Most important, the technique should be simple to understand and operate and produce relevant output in timely fashion. In special context planning, for instance, the need for computerization is open to question. Although forecasting devices (models) can be developed and calibrated with computerized procedures, the use of these models in special context planning may not require—indeed warrant—computerization. Most problems (innovative technologies at the urban scale are a possible exception) involve only a few point-to-point movements and rely heavily on secondary published data, aggregated spatially, as the population base against which models are applied. Models developed should be capable of being applied to such data bases and, most important, should be capable of producing easy-to-understand output in a timely fashion.

A distinct disadvantage of disaggregate techniques (as now employed) is their reliance on complicated statistical fitting procedures for calibration. The analyst derives few benefits from these calibration methods (particularly in forecasting) as opposed to hand-fitting or table look-up calibration methods. Although least squares fitting routines are widely available to transportation planning agencies, maximum likelihood procedures necessary for disaggregate calibration and analysis are not widely known or used, particularly for multichoice models. To the extent that the use of disaggregate procedures is tied to the availability of such tools, the widespread application of these methods in real planning contexts (as opposed to research environments) must remain limited. To the authors' knowledge, few planning agencies have constructed such models and used them in an on-line demand forecasting context [Allen (16) and Winger (20) present exceptions].

Generalization to Other Contexts

Demand estimation methods should be applicable (within similar situations) to other cases and to ranges of variables not now existing. To the extent that the forecast involves new technology applications, care should be taken to include appropriate descriptor variables in data collection, lest rough surrogates be required to extend the model's range.

It is perhaps unreasonable to insist that just one model (or, for that matter, several models) be applicable to different kinds of special contexts. Yet within a particular context group (e.g., university studies) it seems equally unreasonable to insist that separate and distinct methods be developed for each separate case study. Although the basic factors influencing demand and their interrelations are probably not dissimilar from one case to the next, analysts are often unsure of this structure. Given the state of our knowledge, a policy of experimentation and varied studies appears more appropriate than concerted striving for the model appropriate to a given context.

It does not appear that disaggregate techniques per se are more easily generalized in other planning contexts than are conventional procedures. This capability depends not on a model's mechanical attributes such as the method of calibration of specific functional form but on (a) the degree to which the behavioral phenomena involved in those contexts are similar and are driven by the same underlying factors and (b) the extent to which the model (aggregate or disaggregate) extracts the key elements of that phenomena. These procedures do no better than conventional methods in extracting traveler decision processes or describing individual choice behavior. They have been calibrated on precisely the same transportation system descriptors and socioeconomic variables as conventional techniques.

Summary

We have compared disaggregate techniques with aggregate procedures for use in special context planning. Disaggregate procedures appear superior with respect to (a) application to shorter planning horizons, (b) interpretation of demand sensitivity with respect to system variables, and (c) use of small-sample data bases. Aggregate techniques appear easier to calibrate with currently available procedures. The 2 procedures appear about equal with respect to extraction of behavior, incorporation of relevant variables, accuracy, required detail of individual data records, and generalization to other contexts.

DIRECTIONS FOR RESEARCH

We have suggested that the idea that disaggregate techniques are markedly different (structurally) from conventional procedures should be viewed with considerable skepticism. Similarly, although disaggregate techniques possess certain advantages over conventional procudures for special context planning, they should not be seen as panaceas for demand forecasting in these problem areas. Before we can be confident of these tools, we need considerably more research and experience with their properties and applications to demand forecasting in general and to special contexts in particular. The following extensions of current work would be particularly valuable.

1. Extend the range and type of variables included in current disaggregate models, with particular emphasis on qualitative attributes of alternative transportation choices as perceived by potential users and on psychological and hidden attributes of potential users. This work is essential if we are to better understand travel choice processes and is particularly important with respect to studies of special groups.
2. Demonstrate the applicability of disaggregate techniques and incorporate such variables in actual planning contexts. We suffer from an appalling lack of experience with disaggregate procedures in real planning problems. Virtually all of the work in disaggregate techniques to date has concentrated on problems of model form and calibration (i.e., the first stage in demand forecasting), whereas almost no applications of these procedures in actual planning problems exist. Thus, what the relative merits of disaggregate techniques are compared to conventional procedures is a hypothetical question. The time has come to consolidate the gains made in recent years in disaggregate model theory so that further research may benefit from the experience gained from application of the current state of the art.
3. Extend research in travel behavior. The most basic research needs are the structure of individual choice processes. Specifically, we need to know much more

about phenomena such as (a) nontransportation factors influencing choice, particularly pretrip family decision and allocation structures; (b) time-sequencing of travel patterns, i.e., how these patterns are decided on and interrelated to satisfy person and household needs; (c) the process by which travelers perceive the attributes of alternative destinations, modes, and routes and the degree to which these attributes influence choices; (d) traveler evaluation mechanism, i.e., how certain attributes are filtered, selected, scaled, weighted and combined, or traded off in making choices; (e) effects of memory, learning, expectation, and habit on travel choice processes; (f) effects of external information sources on these processes; and (g) effects of weather, traffic accidents, and other random variables on choices and attribute perception.

Clearly, disaggregate modeling by itself cannot address these topics, although it may prove useful as a tool in studying such travel phenomena. Hence we are not calling for more research into disaggregate techniques per se but are suggesting a reorientation of current research. Perhaps the greatest disadvantage of the use of disaggregate models as forecasting tools in special contexts is that current interest in these techniques seems to have blunted and misdirected badly needed research in other topics. We seem to be in danger of attributing to the disaggregate approach to modeling a host of characteristics that appear to make it ideal for evolving transportation planning needs; in reality, it is just an additional tool and no more. The authors grant the advantages of such techniques in calibration, particularly with small sample surveys; but the analyst should not treat disaggregate models as panaceas or, for that matter, as an improvement over current techniques for special context planning.

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