REVIEW DRAFT
OREGON MODELING STEERING COMMITTEE
LONGITUDINAL PANEL SURVEY WHITE PAPER

INTRODUCTION

The last Oregon household activity and travel survey was conducted in 1994 as a cross-sectional revealed preference survey. The physical area covered included urban areas in the Willamette Valley, southern Oregon, parts of the coast, the Columbia Gorge and the Bend-Redmond area. As the Oregon Modeling Steering Committee (OMSC) prepares to update this survey information, it also intends to modify the survey style and begin a longitudinal panel survey in fiscal year 2003, unless persuaded by the Expert Panel that other methods are more appropriate.

There is solid evidence that panel data can significantly enhance the ability to understand and forecast travel behavior. A panel survey is one of the few methods available to the analyst to understand how traveler behavior is influenced by information acquisition, experimentation, and learning. It provides an opportunity to identify behavioral change over time. In effect, the panel survey provides information to understand cause and effect relationships and the process of change.

PURPOSE

This white paper was prepared to accomplish several objectives:

- Address different model forms for implementation, which rely on the survey data to quantify the estimation parameters, or provide information for operation.
- Summarize the goals of the survey and define the subject areas where data is needed.
- Identify the challenges inherent in a panel survey.
- Summarize a survey of the literature to provide information regarding the procedural issues in conducting a panel survey.
- Address needs for additional complementary surveys. (e.g. housing location for movers, stated choice experiments where appropriate).

A brief summary of the research findings is presented, including questions about the research.

PANEL OF EXPERTS

There are many issues to consider before conducting a longitudinal panel survey. Detailed consideration must be given to the survey content, design, data capture methods, and the intended use of the data. Many of the issues require the expertise of survey professionals. At the same time, it is important to understand state-of-the-art modeling techniques to understand how collected survey data can be used.

To provide this expertise, the OMSC will assemble a panel of experts to discuss these complex issues and provide guidance on development and implementation of the survey. Risk factors will be assigned to each of the potential issues that pertain to the conduct and use of the survey. This white paper will serve as a guide for this several day expert panel discussion. The OMSC will use the comments and recommendations of the expert panel members as guidelines for development of the survey work program.

ANALYTICAL NEEDS

For the members of the OMSC to conduct meaningful policy analysis for decision-makers, it is necessary to collect current information regarding housing choices, automobile acquisition, and travel behavior. The 1994 survey captured activity and travel choices of respondents. It is timely to update this data and to obtain additional information not addressed in the 1994 survey.

Design of the new survey needs to capture the following information:

- Housing location choice.
- Urban design environment and its impact on travel choices.
- Auto acquisition and disposition.
- Household transition effects (life cycle).
- Household/personal income effects – Identify how disposable income and consumption behavior impact travel and location choices.
- Technology profile - Identify how location and travel decisions are affected by computers, e-mail, cell phones, etc.
- Dwelling unit information - Identify the changes in type chosen (single-family vs. multi-family, suburban vs. urban, etc.) as it relates to income and lifecycle.
- Seasonal travel differences – Identify how travel characteristics change between summer, winter, and other seasons. May affect air quality considerations.
- Attitudes and values – Determine how attitudes and value systems influence travel choices.
- Activity and travel choices – Determine choice patterns for activities. Identify travel tours, trips, destination, and mode choice patterns.

MODELING CONSIDERATIONS

Model Forms

One use of the survey data is to build modeling tools for use in estimating travel demand. Research indicates that there are multiple theoretical approaches that have been developed. Forms include utility maximizing models, constraint-based models, computational process models, and micro-simulation models. It is important to understand the advantages and disadvantages for each of these. The OMSC desires to build models that are practical to apply, operationally simple, and theoretically sound. The expert panel will provide insight on the use of data for different modeling tools.

Model Structures

Utility Maximizing Model

This model assumes that an individual selects an alternative that maximizes his utility. There is some criticism of this theory because it assumes that an individual is able to consider full information about all the available choices and then optimizes. Not all decisions are based upon having the full information about all the choices and it is probable that real choice behaviors are satisficing. Nonetheless, most operational transportation models are based upon this theory. In a sense, in microsimulation applications that use this theory *and* are applied using a sampling procedure where each activity pattern, mode and destination choice set face a limited subset of destinations there is a practical satisficing element implied.

Advantages:

- Very familiar model structure, we have a good understanding of its use.
- Can be used as both a "state" model and a model of change from a known pattern.
- Can be used to create a "base" scenario, particularly if using stochastic microsimulation, for use with other (e.g. Computational Process) models for change – adjustment of behavior of individuals.

Disadvantages:

- While the model form uses regression techniques, it is a model of correlation, not cause and effect, in essence not behavioral. Because of correlated variables it is easy to get spurious relationships that "work" (includes both variables within the model and, unfortunately, variables perhaps not considered).
- It is also assumed that behavior is optimizing with perfect information about a large number of alternatives. This large number of alternatives is clearly beyond the abilities of human cognition.

Constraints-based Model

These models examine whether particular activity patterns can be realized within a specified time-space environment. These models require a set of activity patterns. The activities are of a certain duration and can be performed only at certain times. The intent in TRANSIMS was essentially to use a variant of this approach.

Advantages: An elegant and intellectually appealing approach.

Disadvantages:

- Difficult to operationalize.
- No good examples of use in general practice.
- Needs a set of activity patterns as a starting point. This can be generated synthetically using synthetic household generation and mapping a household activity set from a home interview survey onto like households randomly.

Computational Process Model

This model incorporates both constraints and choice in the decision process and is based upon choice heuristics. The model accounts for imperfect information and sub-optimal choice sets. Logical rules are used to simulate the behavior of interest rather than using algebraic equations. One advantage these models have over constraints-based models is that they incorporate mechanisms to predict adjustment behavior of individuals. In practice TRANSIMS seems to be in this category, as does the work of Kitamura et al for a project in Washington DC. (AMOS?)

Advantages:
- Intellectually appealing, seems to mirror the cognitive abilities of humans.
- Can be made to work using heuristic learning processes.

Disadvantages:
- Is essentially a model of behavioral adaptation. As such it needs a data-set of surveyed households – feasible in a limited study, but not for regional analyses. It is likely that a hybrid approach could work here, using other model forms to develop a large enough set of synthetic households, with activity patterns, that could then be used for further analysis of alternatives and change.

Microsimulation Models

Microsimulation models simulate the behavior of individuals (rather than groups or categories in an aggregate approach). The above model categories can be applied either way, but for many reasons (desire to include household life cycle effects, land use environment effects, desire to enable equity analysis capability), a microsimulation approach is an assumed outcome for activity-travel pattern modeling in this study.

Advantages:
- Is essential for a full accounting of household structure impacts – can handle a complex array of socioeconomic and environmental variables in a practical manner.
- Is easy to apply and fast.

Disadvantages:
- Cannot be applied within current packages – matrix-based approaches defeat the objective – computationally intractable.
- Needs custom programming.

Recent Model Development Activities

New ideas continuously emerge in the area of model development. The tabulation below summarizes some of the most recent work.

Activity Frequency Analysis and Activity Participation

- Ma and Goulias (1999). Poisson-related models to predict the frequency of subsistence, maintenance, and out-of- home leisure activities.

- Kockelman (1999). Used multivariate negative binomial model to derive a system of demands for activity participation.
- Lu and Pas (1997, 1999). Structural equation modeling to participation, and travel behavior.
- Bowman and Ben-Akiva (1999) Activity-based disaggregate travel demand model system with activity schedules.
- Bowman Ben-Akiva, Bradley Shiftan and Lawton et al: (1998) Demonstration of an activity based model system for Portland.
- Bradley, 2001: Estimation of Activity Based Microsimulation Model for San Francisco.

Activity Duration and Time Allocation

- Kitamura, et al. (1992). Used a loglinear model for commuting distance and activity duration.
- Kitamura, et al. (1998). Activity duration was incorporated into a destination choice model.
- Kitamura, et al. (1996). Tobit model based on the principle of utility-maximizing behavior that incorporated unobserved heterogeneity.
- Bhat and Misra (1999). Continuous utility-maximizing resource allocation problem.
- Kitamura, et al. (1997). Developed a structural equation model system that explains commuter time use and travel after work.
- Golob and McNally (1997). Modeling activity and travel choice of different household members simultaneously.
- Mannering, et al. (1994). Estimated a Cox proportional hazard model to predict the duration of home-stay duration.
- Bhat (1998). Used a non-parametric baseline hazard model, incorporating heterogeneity in duration.
- Misra (1999). Argued that duration was not a true continuous variable. Modeled activity duration as a Poisson process.

Trip Chaining and Stop Pattern Formation

- Strathman, et al. (1994). Analyze trip-chaining patterns of different household types.
- Timmermans and van der Waerden (1993). Showed how universal logit models can be used to estimate the above.
- Timmermans (1996). Showed generic model specification can be generalized to build alternative-specific models.

Number of Stops

- Jou and Mahmassani (1998). Used Poisson regression model.
- Bhat (1999b). Used a less restrictive model structure and incorporated unobserved heterogeneity,

- Bhat (1999c). Used an ordered-response logit structure to model the number of stops and the number of stops made in activity-chaining categories.

TASKS PERTAINING TO SURVEY ADMINISTRATION

The Expert Panel will discuss tasks and issues that must be considered when conducting a survey. The following key points will be addressed in defining survey administration.

Tasks

Survey Design

There are multiple types of survey designs available to the analyst. Single cross-sections, repeated cross-sections, regular panel, rotating panel, split panel and others have all been used in data capture. (See pages 9-12 for a description of each). The current bias on the part of the OMSC is for a panel or rotating panel survey.

Recruitment

The recruitment process for populating the panel may be troublesome. High refusal rates may be encountered due to non-interest, security concerns, distrust, etc. Methods need to be developed to minimize this difficulty. This difficulty is common to all household surveys, not just panels. The use of random digit dialing as a recruitment method leads to a significant non-response bias in that the least active households are more likely to be successfully recruited.

Consideration of other ways of selecting and recruiting samples will be a part of this process. Mainly address based sample frames and some direct contact with the household (for recruitment or for actual data capture).

Sample Selection

Sampling techniques are an important element of any survey. Decisions must be made with regard to the sampling size, stratification of samples, geographic distribution, etc. This will be driven to a large extent by the analytical needs and policy dimensions desired. The question of sample timing is also important – short period or year-round?

Data Capture Methodology

With new technologies, data collection methodologies have continually evolved. Some of the techniques available today include person-to-person interviews, telephone retrieval of diary data, web-based systems, palm pilots with global positioning satellite capability, Web-TV, and others. Some approaches use elements from several of these techniques. For example using GPS for passive collection of travel data (location, speed, stops by time) and using that framework to do a prompted recall for activities at

locations and removal of spurious stops (addition of stops not identified). The challenge is to select the technique that is both cost-effective and comprehensive.

ISSUES

Non-Response Bias

Survey response bias can be present in many ways. Non-reporting of data can occur when an interviewee intentionally or inadvertently fails to provide information. Some bias can occur if the interview samples are not chosen in a manner that reflects the population distribution. Age, income, worker and household size cohorts must all be respected, although these last two are easily rectified with post-hoc weighting. Perhaps the most egregious bias is that of the likelihood of contacting households that are the least active in terms of out-of-household activities (the subject of interest). There is no straightforward way of correcting for this bias short of making ad hoc assumptions that can lead to calibration of model output with secondary data sources (counts, etc.). This issue must be addressed with the problem areas being both recruitment and retention.

A panel survey approach offers some special challenges. As members of the interview panel are replaced through time, bias is introduced when new households are introduced into the sample. It is important to minimize this bias to the extent possible.

Attrition

Members of a panel survey will drop out from time to time, as a result of members leaving the area, loss of interest, or other reasons. Research suggests that attrition rates are higher for low-income households, smaller households, households without cars, and those with lower levels of education.

A variety of methods exist that attempt to minimize attrition. Cash or prize incentives, regular reminder calls, concerted tracing, and questionnaire updating have all been used to maintain survey participants. It is important to evaluate and identify techniques to keep attrition to a minimum.

Stagnation

Over time, the profile of the panel may no longer fit that of the population as a whole. For example, the group is constantly aging and income characteristics will likely change. As panels are updated, care must be taken to ensure that the update process is statistically sound. Methods must be used that efficiently maintain a representative panel.

Evaluation Design

A large amount of important data will be collected from the survey participants. It is imperative that the information be utilized to the fullest degree possible. The analyst must be able to address the high degree of variation of individual behavior within a

relatively stable aggregate environment. Comprehensive and efficient analytical techniques must be developed for this process.

ISSUES PERTAINING TO MODEL DEVELOPMENT

The Expert Panel will discuss various issues that need to be considered when using survey data. This section summarizes key points that must be addressed in the area of model development.

Cross-sectional versus Longitudinal data

Many analysts are familiar with the use of cross-sectional data gathered in revealed preference surveys. Both trip-based and activity-based models have been built using this data.

Longitudinal data is different. The sample sizes are typically smaller and the data collection period is not static but continues over a long timeframe. These characteristics require different analytical techniques. When this data is used for model building purposes, the analytical approach needs to be appropriately modified.

SUMMARY OF RESEARCH

Staff from OMSC agencies has conducted research to identify surveying techniques and the application of the data collected in model development. The following findings are summarized by topic area.

Survey Design

Single Cross-sections

Most household surveys used for transportation modeling purposes use a single cross-section survey design. This style provides the analyst information for a distinct point in time.

Advantages:
- One time funding commitment.
- Very familiar exercise.

Disadvantages:
- Expensive, requiring a large short-term outlay.
- Does not provide information about changes through time. Response to changes in the household's living environment.

Repeated Cross-sections

This survey design collects data continually, but not from the same households or individuals. This technique features the collection of distinct data at a point in time.

Comparisons through time can be determined by comparing information from like cohort groups. The American Community Survey is an example of this type.

Advantages:
- Comparisons over time can be made within homogeneous groupings.
- Helps to avoid "panel conditioning", a situation where a panel member becomes familiar enough with the questions that he begins to alter his behavior and/or his survey responses.
- Helps to avoid panel attrition problems due to apathy, burden, etc.

Disadvantages:
- Unable to measure changes from an individual perspective.
- Cannot aggregate data for an individual over time.

Panel Surveys/Longitudinal Surveys

This survey type repeats measurements on the same set of individuals or households over time.

Advantages:
- Ability to capture detailed behavioral changes over time.
- Can estimate net changes with greater accuracy than when using a repeated cross-section design.
- Sample can be aggregated over time by combining data from several waves.
- Can measure gross change while repeated cross-sections can measure only net changes.
- Contributing patterns to the decision process can be observed.
- Expense can be spread over a long period of time – easier to fund.

Disadvantages:
- Response bias is created due to attrition of the survey sample between waves. This can potentially lead to misleading conclusions.
- Panel conditioning and fatigue can occur through time. Conditioning occurs when respondents are repeatedly subjected to the same survey over time. Fatigue can occur when the survey is too long and burdensome.

Rotating Panel Surveys

This survey is similar to a panel survey, except that different households or individuals are used after a given number of waves (greater than one and probably less than five).

Advantages:
- The potential bias due to non-response, conditioning, and stagnation is minimized.
- More precise estimates at a distinct point in time are given than with a repeated cross-section.
- This is a better design for comparison of mean parameter estimates over time than with a repeated cross-section.

Disadvantages:
- Not useful for the aggregation of samples over time.

Questions:
- Why can a rotating panel survey not be used for aggregating samples over time?

Split Panel Surveys

This survey technique uses two groups: a panel and a cross-sectional sample.

Advantages:
- Provides the best estimate of net change.
- Incorporates the benefits of panel surveys and the large sample size of cross-sectional surveys.
- Parameter estimations can be made for a distinct point in time using the non-panel group.

Disadvantages:
- The expense is high due to the many samples.
- Two separate surveys must be conducted at the same time.

Questions:
- Is it feasible to create an alternating cycle between a panel survey and repeated cross-section survey?

Sample Selection

Sampling Techniques

Many types of sampling methodologies are used in surveys.
- Random sample: sample is randomly drawn for an unbiased model selection.
- Cluster sample: sample is randomly drawn by household types or other clusters.
- Choice-based sample: focus on certain groups that have unique behavior traits (e.g., park and ride, transit, or walk/bike groups).
- Stratified sample: over-sample certain areas where targeted behaviors are desired (e.g., urban, very urban, suburban).

Random Digit Dialing

Random digit dialing is almost always used as a tool to recruit population samples. However, problems have been identified with this technique:
- It is getting harder to identify household telephone numbers by location. Prefixes are no longer geographic.
- Many households have a single line but use it for both voice and Internet communication. Thirty five percent of all households own a computer. Eleven percent of them subscribe to an on-line service (1996 Odyssey World Wide Web Survey).
- It is getting harder to reach people at home. The most active never get sampled.
- Many households have replaced their home phone line with mobile phone service.

Questions:

- What is the best practice for selecting the survey population?
- How many samples are needed to estimate the many parameters found in complex transportation models?
- Have dual frame sampling techniques been used (e.g., area probability and random digit dialing)?
- Many households are using mobile phones. How are random digit dialing techniques affected by this? How much bias is added when mobile phone users are missed?
- Should we consider a return to address-based sampling followed up with mail contact and, at least, personal survey initiation by a visit to the household?

Survey Collection Methods

Survey Collection Methodologies

Four collection methods receive the most use in practice:

- CATI: computer-assisted telephone interview.
- CAPI: computer-assisted personal interview.
- CASI: computer-assisted self-interview.
- CAWI: computer-assisted web interview.
  Is it time to reconsider a fifth (old practice)
- IHPI: in-home personal interview?

The current practice in Oregon uses random digit dialing sampling followed by a mail-out diary package. The information is retrieved using a telephone interview.

Internet Methods

Advantages:

- The Internet can provide a good visual appearance that can make the response process easy and "fun" for the participant. This assumes that the participant has no fear of computers and web-based applications.
- Software can provide more response options. This feature makes it easier for the participant.
- The participant can answer the survey at the time of their choosing.

Disadvantages:

- Computer and Internet access is not universal.
- If Internet methods are mixed with other techniques, bias can be introduced into the survey.

Questions Regarding Data Collection

- What is the best design when the population sample is recruited using telephone or mail-based methods, then retrieved using a mixed collection technique?

- If mixed collection methods are used, what are the best ways to minimize the introduction of bias?

Non-Response Bias

Response Rates

Non-response can be classified into two categories: refusals and non-contact. There is a large growth in the "unknown" category. This situation arises when the phone is not answered or is busy over multiple contacts. Response rates are pertinent in four different areas:

- Non-contact rates
- Refusal rates
- Incomplete rates
- Final respondent rates

Literature suggests the following techniques for improving the response rate:

- Good interviewer techniques.
- Use of lead letters and presentation.
- Personal (real) contact?
- Questions must be simply structured and easily answered.
- Survey contractor must be experienced.
- Keep the respondent burden manageable.
- Record the interviews and have trainees critique themselves.
- Use pre-paid incentives via express or priority delivery.
- Use multiple follow-ups to capture households.

Questions

- Are refusals still the dominant reason for non-response? Is the inability to contact households the greatest obstacle?
- How can we distinguish random non-response bias from the bias introduced by the attrition between waves?

Attrition

Attrition can introduce errors into standard model estimation methods.

Questions

- How can a high degree of attrition be prevented?
- What is the best statistical method to use to minimize the bias due to attrition?
- How can the burden and fatigue of the respondent be reduced?

Stagnation

Stagnation occurs when the panel members no longer represent the population at large.

Questions

- What is the most logical approach for updating the panel?
- How can the continuity of the panel be maintained when regular adjustments are necessary to reflect the profile of the population?

Evaluation Design

Questions

- What types of analytical techniques should be employed to derive full benefit from the information garnered from the panel survey?
- How is the high variability of an individual's patterns evaluated within the context of a relatively stable aggregate analysis?

REFERENCES

Bradley, M. (1997) A Practical Comparison of Modeling approaches for Panel Data. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 11.

Goilias, K.G. and Kitamura, R. (1997) A Dynamic Microsimulation Model System for Regional Travel Demand Forecasting. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications,, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 2.

Golob, T.F., Kitamura, R. and Supernak, J. (1997) A panel-Based Evaluation of the San Diego I-15 Carpool Lanes Project. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications,, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 4.

Giuliano, G. and Wachs, M. (1997) An Employer Panel for Evaluating the Effectiveness of Trip Reduction Incentives. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS. Chapter 5.

Hensher, D.A. (1997) The Timing of Change: Discrete and Continuous Time Panels in Transportation. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 12.

Meurs, H. and Ridder, G. (1997) Attrition and Response Effects in the Dutch National Mobility Panel. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 8.

Murakami, E. and Ulberg, C. (1997) The Puget Sound Transportation Panel. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS, Chapter 6.

Paaswell, R.E. (1997) Why Panels for Transportation Planning. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS, Chapter 1.

Pendyala, P. and Kitamura, R. (1997) Weighting Methods for Attrition in Choice-Based Panels. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation Planning Methods and Applications,, Kluwer Academic Publishers, Massachusetts, UAS., Chapter 9.

Raimond, T. and, Hensher, D.A. (1997) A Review of Empirical Studies and Applications. In Golob, T.F, Kitamura, R., Long, L, ed., Panels for Transportation

Planning Methods and Applications, Kluwer Academic Publishers, Massachusetts, UAS. Chapter 2.

RELATED WORK

Arentze, T., Borgers, A., Ponje, M. and Timmermans, H. (2000)Effects of Respondent Demand on Response Rates and Quality of Multi-Day Activity Diaries, Transportation Research Board paper presented at the January 2000 TRB Conference.

Duncan, G.J. and Hill, M.S. (1984) Conception of Longitudinal Households (Draft). Institute for Social Research, University of Michigan. Ann Arbor.

Duncan, G.J. and Hill, D.H. (1985) An investigation of the Extent and Consequences of Measurement Error in Labor Economic Survey Data. Survey Research Center, University of Michigan, Ann Arbor.

Duncan, G.J. and Kalton, G. (1985) Issues of Design and Analysis of Surveys Across Time. Paper to Centenary Session of the International Statistical Institute, Amsterdam.

Golob, J..M.., Schreurs, L.J.M. and Smith, J.G.(1985). The design and policy applications of a panel for studying changes in mobility over time. In Behavioral Research for Transport Policy, VNU Press, Utrecht, The Netherlands, 81-95.

Golob, T.F. (1987) Dynamic analysis of complex travel behavior using a subsample of the Dutch Mobility Panel. Institute of Transportation Studies, University of California, Irvine.

Golob, T.F. (1989) The causal influences of income and car ownership on trip generation by mode. Journal of Transport Economics and Policy, 23, 141-162.

Golob, T.F. (1990) Structural equation modeling of the dynamics of travel choice dynamics. In P. Jones, ed., Developments in Dynamic and Activity-Based Approaches to Travel Analysis, Gower Publishing Co., Brookfield, Vermont, 343-383.

Golob, T.F. and Meurs, H. (1986) Biases in response over time in a seven-day travel diary. Transportation, 13, 163-81.

Hensher, D.A. (1985) Longitudinal surveys in transport: An assessment. In E.S. Ampt, A.J. Richardson, W. Brog, eds., New Survey Methods in Transport, VNU Science Press, Utrecht, The Netherlands, 77-97.

Hensher, D.A.(1987) Issues in the pre-analysis of panel data. Transportation Research, 21A(4/5), 265-285.

Hensher, D.A.(1997). The timing of change: Discrete and continuous time panels in transportation. Chapter Twelve in this volume.

Hensher, D.A. and Smith, N.C. (1985) Longitudinal surveys. Workshop Summaries in E.S. Ampt, A.J. Richardson, and W. Brog, eds., New Survey Methods in Transport, VNU Science Press, Utrecht, The Netherlands, 41-44.

Hsiao, C. (1986) Analysis of Panel Data. Cambridge University Press, Cambridge.

Kish, L.(1985). Timing of surveys for public policy. Australian Journal of Statistics, 28(1), 1-12.

Kitamura, R. (1988) A dynamic model system of household car ownership, trip generation and modal split: model development and simulation experiments. Proceedings of 14th Australian Road Research Board Conference, Part3, Australian Road Research Board, Vermont South, Victoria, Australia, 96-111.

Kitamura, R. (1987) A panel analysis of household car ownership and mobility. Proceeding of Japan Society of Civil Engineers 338/IV-7(Infrastructure Planning and Management), 13-37.

Kitamura, R. (1990) Panel analysis in transportation planning: An overview. Transportation Research, 21A(6), 401-415.

Kitamura, R. and Bunch, D.S. (1990) Heterogeneity and state dependence in household car ownership: A panel analysis using ordered-response probit models with error components. In M. Koshi, ed., Transportation and Traffic Theory, Elsevier Science Publishing Co., Amsterdam.

Kurth, D.L., Coil, J.L. and Brown, M.J.(2001), An Assessment of Quick-Refusal and No-Contact Nonresponses in Household Travel Surveys, Transportation Research Board paper 01-2761 presented at the January 2001 TRB Conference.

Snellen, D., Arentze, T., Borgers, A. and Timmermans, H. (2001) Spatial Variability in Response Rates and Data Quality of a Designated Days-Leave Behind-Full Activity Diary, Transportation Research Board paper presented at the January 2001 TRB Conference.