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Updating a Panel Survey Questionnaire

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Abstract

In a panel survey where the same set of questions is asked repeatedly over time, the need to update the survey questionnaire may arise. Knowledge of the quality of earlier responses can be used to improve the questionnaires for subsequent waves. Response rate and item non-response can be improved through information obtained in earlier waves. Changes in layout, appearance, number of questions and wording, influence the quality of the responses. However, the need for continuity of the questionnaire's content and appearance across waves, substantially limits the choices for redesign. Therefore, the redesign of a questionnaire is a constrained problem with an ultimate objective of increasing the response rate, item response, and accuracy of the responses, within the limits imposed by the need to maintain continuity.

A travel impact analysis conducted in connection with the State of California Telecommuting Pilot Project offers an opportunity to study panel questionnaire updating. The process of updating a three-day travel diary is documented, and its effects on trip reporting and reporting accuracy are discussed in this paper. The results indicate that improved wording and layout contribute to improved data quality, but do not help to prevent under-reporting of trips due to panel fatigue.

1. Introduction.

A promising approach to travel behavior analysis, which has drawn a considerable amount of attention in recent years is panel analysis. Panel analysis is based on longitudinal observations of the same set of behavioral units. Its strength is that repeated observations of the same individuals or households provide the history of their behavioral changes. This makes the identification of causal factors and relationships a much more practicable task. The confounding effects of individual-specific factors that do not change over time, can be accounted for with panel data. Moreover, panel data allows the construction of dynamic models that forecast future demand based on systematic tendencies in longitudinal changes, rather than on cross-sectional variations across behavioral units. Panel analysis also addresses the dynamic aspects of travel behavior significant in many planning contexts; including behavioral turnover (e.g., mode switching), learning and experimentation (e.g., about a new bus line), and long term vs. short term elasticities (of car ownership to household income).

Panel analysis is being applied to an ever-increasing number of studies in transportation planning (e.g., Hensher, 1986; Kitamura, 1989; and Golob & Golob, 1989) and several large-scale panel surveys are being planned (e.g., Murakami & Watterson, 1989; and Purvis, 1989). The development of panel survey instruments, however, involves added complexities arising from unique problems such as attrition, panel conditioning and decreasing response rates. The effort also involves a new element; that of updating panel questionnaires between waves of the survey.

In a panel survey the researcher often has the opportunity of examining responses to the questionnaire from an earlier survey wave. Deficiencies, which the researcher may wish to rectify for the subsequent waves, may become apparent. However, the objective of a panel survey is often to examine changes in responses to the same set of questions. Therefore, it is necessary that correction, or updating, of the questionnaire does not impair the comparability of responses. Obvious design improvements may not help if they interfere with the continuity. Updating a panel survey questionnaire is thus constrained by the need to maintain continuity across survey waves.

This paper presents a discussion on panel survey questionnaire updating, using the ongoing State of California Telecommuting Pilot Project (Goulias, et al., 1989) as a case study. Telecommuting refers to the use of telecommunications technology, such as the telephone, to perform work tasks at home without commuting to the workplace (Kitamura, et al., 1990a). The project involves a special purpose panel survey that aims at identifying the impact of telecommuting on individual and household travel patterns. The questionnaire used in the first survey wave was modified and used in the second wave, which took place approximately one year later.

This paper discusses the updating process, in detail, and examines the quality of the responses of the two survey waves. The study sample consists of two groups: telecommuters (the portion of the sample working at home at least one day a week) and the control group (the portion of the sample not telecommuting). This not only allows the isolation of the impact of telecommuting on travel, but also allows the evaluation of

the changes made in the survey questionnaire. However, it is not possible to separate the effects of the updating procedure from the effects of possible changes in factors affecting travel behavior (fuel prices, new bus lines, etc.) between the two waves.

The objective of this paper is to assess the impact of updating the questionnaire on trip reporting, to present the stages followed in that updating and to illustrate how a panel survey questionnaire can be improved without introducing a loss of continuity. The success of the updating procedure is evaluated through the use of trip reporting rates.

The following section is a literature review on questionnaire design and other components of travel surveys. Section 3 describes the panel travel survey procedure and the instrument of the State of California Telecommuting Pilot project. The focus of discussion is the updating process followed to prepare the questionnaire for the second wave. Conclusions are outlined in the last section.

2. An overview of surveys

While questionnaire design for panel surveys has much in common with that of cross-sectional surveys, it involves some unique aspects, (e.g. issues related to the use of travel diaries in repeated interviews; see Golob, et al., 1986). Unfortunately the literature on panel survey questionnaire design is limited. Madow, et al (1983a, p13) note "Theoretical and empirical research should be undertaken on methods dealing with nonresponse in longitudinal and panel surveys."

2.1 Survey Instrument, Procedure and Data Quality

The quality of survey results may be impaired by problems arising from a variety of sources. These include sampling errors, errors due to incomplete data, response errors, and processing errors (Madow, et al., 1983b). Sources of sampling bias include low response rates, low completion rates, item nonresponse, difficulty in locating respondents in a longitudinal survey when following up the initial sample, and inadequate sample coverage. These would not be a problem if non-response is proven to be random; otherwise, the sample statistics may not be representative of the population. It is important to understand the reasons for non-response or erroneous responses and to devise methods to overcome their negative consequences. Although there is apparently no definitive agreement on what is most effective (Yu and Cooper, 1983), a variety of countermeasures have been suggested. These can be grouped into a priori and a posteriori measures.

A Priori Methods to Reduce Non-Response

A priori methods are those implemented before a survey is conducted. They include improvements in questionnaire design, pretesting, and improvements in survey administration procedures. Possible relationships between these elements and survey responses have been discussed extensively in the literature. A brief discussion of these methods follows.

Method of contact: Personal interviews have the highest response rate (Wermuth, 1979) and present the added advantage of collecting more detailed information about the respondent (Brog, et al., 1983).

Questionnaire Length: Possible biases due to item non-response and response inaccuracy may be attributable to excessive length (Yu and Cooper, 1983).

Question Length: Provided they are not embarrassing, short and clear questions are preferable (Blair, et al., 1977) and vice versa.

Response facilitators: A significant positive effect can be triggered by preliminary notification, 'foot-in-the-door' techniques (Reingen and Kernan, 1977), personalization, follow-up letters and instruction sheets (Cannell, et al., 1977). Appeal, a quality that arouses interest or sympathy, is a subliminal influence and has been studied by Houston (1981). He reports that appeal is very important and can significantly increase the number of completed questionnaires. The effect of appeal is not only beneficial on the response rate, but also on the speed and completeness of the responses.

Forsythe (1977) presents an example of possible detrimental effects caused by personalization in a survey of business executives. A cover letter, assurances of anonymity, stating a deadline, and provision of postage, on the other hand, do not appear to show significant effects. The influence of survey sponsorship and call-backs is unknown.

Questions and Their Sequence: Also important are the clarity of questions, uniqueness of the answer, wording, sequence of questions and their format (Brog and Ampt, 1983; Sheskin and Stopher, 1982).

Layout: Enhancing the questionnaire layout can improve the response (Sheskin and Stopher, 1982; Heathcote, 1983). Pressley and Tullar (1977) found that the color of the survey questionnaire and the presence of cartoons have no significant effect on the response rate. According to Brog, et al. (1983), a column layout seems to improve response accuracy. They report that a column layout yielded 3% of unusable or partly unusable questionnaires compared to 8% for a row layout. The importance of questionnaire layout is demonstrated by Mayer and Piper (1982) in their surveys, conducted in two different years, which indicated completely reversed tendencies of purchasing a product. The replacement of a line for a box was later verified, by phone, to have confused the respondents. In another study, lack of adequate space to report answers is claimed to be a reason for item non-response. In contrast, when the question asked is about subjects the respondents are familiar with (e.g., income) even substantial changes in the questionnaire do not result in any inaccuracies. An example of this can be found in an experiment by Herriot (1977) who used a panel to assess the effect of different questionnaire formats on the accuracy of the answer.

Interaction between Interviewer and Interviewee: An excellent analysis is presented by McKenzie (1977) on the influence of the interviewer on response quality. The personality of the interviewer seems to influence the way interviewees answer the questions. Extensive training of the

interviewers seems to be a solution to this problem. This is particularly important when complex questions are involved (Bailar, et al., 1977). The effect of interviewers on quality of information collected in a panel survey is reported by Hensher (1985).

Instructions: A large portion of guidance for completing a questionnaire is often provided by an instruction sheet. The instructions, according to Cannell, et al., (1977), have to clarify to the respondent what is expected of him, guide him in such a way that he will be more efficient and motivate him to answer all the questions.

If the above guidelines are adhered to in developing an instruction sheet, then the absence of an interviewer is partially overcome and his contributions in reducing respondent errors and improving item-response rates can partially be replaced.

Administration and Coding: This is another important component of a satisfactory survey design. Administration includes delivery, follow-up and collection of the survey instrument (Clark and Goldstucker, 1986; Brog, et al.,1985b). Coding is a very sensitive part of data processing. Specific procedures should be defined in order to avoid biases due to erroneous data entry (Payne, 1977).

Incentives: Monetary incentives, prepaid or promised, have a very strong positive effect on the quality of responses (Yu and Cooper, 1983; Wiseman, et al., 1983). The amount of the incentive is highly correlated with the response rate. Pressley and Tullar (1977) claim that a dime (10 cents) increased the response rate by a surprisingly high 10%. The same tendency is reported by Walsh (1977), although the effect was not of the same magnitude. Offering other incentives appears to have some influence, although there are not many studies where non-monetary incentives are examined.

A Posteriori Methods to Reduce Non Response

Even after every effort is made to improve the survey instrument and procedure, it is likely that the resulting data will contain deficiencies that require attention (O'Muircheartaigh, 1978). The methods that can be used a posteriori can be classified into several categories.

The first is simply to disregard the respondent if required information is missing. The second is to replace the respondent with a "matched" new respondent using a selected set of observable variables (Kalton, 1983a, 1983b). The assumption in this method is that the "matched" new respondent will have the same behavioral characteristics as the dropped one. Usually the verity of this assumption cannot be tested. Both methods lead to sampling bias if item non-response is not purely random, and in the case of the matching method, the variables used for matching do not entirely account for systematic tendency in non-response. The third alternative is to infer values of the missing variables from the context (i.e. from other responses of the same respondents).

A fourth method is *a posteriori* editing and correction of suspected erroneous responses (Heathcote, 1983). Durand, et al.,(1983) suggest "fixing the data" case by case after reviewing each respondent's

record in detail. With regard to this method, a Panel on Incomplete Data was established in 1977 by the Committee on National Statistics (U.S.A.). The discussions of this Panel have been summarized in Madow et al (1983a). A brief review of their recommendations follows:

- -It is preferable to recover non-response using a priori methods than using a posteriori methods.
- -Non-response should be reported in detail and its causes identified in order to enable researchers to recover the missing information.
- -Statistical methods to recover from the detrimental effects of non-response do exist; however, bias will always persist even after a posteriori methods are used.
- -Imputation and weighting are two of the methods which can be applied successfully when needed (in addition see Rubin, 1987).
- -Expected biases given by models based on statistical methods are not better than observed ones. Of course, in many studies observed biases cannot be measured.

An a posteriori method of a different nature has been suggested by Stopher and Meyburg (1979). This is called the "blanket approach" and involves sending letters of gratitude and reminders to all the respondents at a later stage of the survey when a possible problem of non-response has been identified. Whoever did not respond would probably feel obliged to respond at this point and those who did respond earlier would be motivated to answer future contacts. Pretesting is found to be useful to both the respondents (in identifying potential problems) and the administration (Hunt, et al., 1982; Ampt and West, 1985). Increasing the sample size is a last resort which is applied only in cases of extreme need. It is questionable if this last approach solves the problem when systematic tendencies exist in non-response.

2.2. Panel surveys and questionnaires.

Designing an instrument for a panel survey is more complex than that for a cross-sectional survey because it involves additional problems. Potential problems associated with panel surveys are identified and discussed in this section.

Attrition: Selective attrition and panel conditioning are unique to panel surveys (Golob and Golob, 1989). Self-selection always occurs when a survey sample consists of volunteer respondents, for whom no mechanism exists to enforce participation. If self-selection is systematic with respect to measures of interest (i.e., the probability of participation varies from individual to individual as a function of this interest) then the resulting sample will produce biased inferences. This is the case for both cross-sectional surveys and panel surveys. Specific to panel surveys is self-selective attrition, (i.e., self-selective dropout of respondents).

Fortunately, the problem of panel attrition is easier to correct than the non-response problem. The presence of respondents in earlier wave(s) implies the availability of measures of their attributes, including behavioral measures on which attrition is based (Wissen and Meurs, 1989). This allows the analyst to construct a probabilistic model of attrition, which in turn can be used to develop weights to correct for attrition biases (Hensher, 1987). Kitamura and Bovy (1987) have shown that such weights can be constructed for trip generation analysis, based on a system of trip generation models at multiple time points and a probabilistic model of attrition behavior.

Panel conditioning: Since the same respondents are contacted repeatedly and answer similar (or identical) questions over time, they are subject to a phenomenon known as panel conditioning. The effect may be due to the respondent's attempt to appear consistent across waves of the survey.

Consider the case where a panel survey is conducted to evaluate the interplay of attitudes and behavior before and after a change in the travel environment. An example can be found in Supernak and Kitamura (1989) where the change in commuters' attitudes toward car-pool lanes before and after their opening is studied in connection with their car-pool behavior. In such cases the respondents may recall their earlier responses and so adjust their responses in a later wave in order to be consistent across the waves, or to exaggerate their reaction to a change. Hence, panel conditioning is especially suspect when attitudinal questions are involved. Another cause of panel conditioning is a change in perception, attitude, and possibly behavior itself, that may take place because of the increased awareness of the survey subject, as a result of participating in the survey.

Panel Fatigue: Another problem specific to panel surveys is panel fatigue which yields a decrease in reporting accuracy. There are many conceivable sources (e.g., loss of motivation after answering similar questionnaires over time). Meurs, et al. (1989) illustrate this problem using the case of the Dutch National Mobility Panel. In addition to the declining reported trip rate in a weekly diary (which may be viewed as a case of short term fatigue), Meurs, et al. noted that the trip rate reported by the same respondents for the first day of the weekly diary tended to decline in later waves of participation. Such a fatigue effect seems to exist in our panel survey on telecommuting.

"Recruitment" of Initial Respondents: Because a panel survey in general demands a long-term commitment on the part of respondents, it appears to be a common practice to "recruit" them, rather than to randomly sample them. In the case of the Dutch National Mobility Panel, households sampled in a pre-survey were asked whether they were willing to participate in a panel survey which was to continue for several years. To the author's knowledge, no effort was made to include in the panel, those households that declined to participate in this initial survey.

Sample Refreshment: Because of self-selective attrition and other reasons (residential relocation, household dissolution, death, etc.), the number of respondents in a panel gradually declines over time. At the same time, new members enter the study population through birth,

marriage, and migration. This necessitates constant updating of the panel composition, or sample refreshment, if it is desired that it reflect the study area population composition. This may require the continuous collection of information on immigrants (van de Pol, 1987).

The effort spent in sample refreshment can be reduced significantly if the panel is refreshed by replacing drop-outs with new respondents, selected according to pre-specified, observable attributes. This method was used in the Dutch National Mobility Panel survey in which refreshment households were sampled according to household income and life-cycle stage. The distribution of new households in these two dimensions was matched to that of the households that had dropped out. The method, however, may not have been adequate because such measured attributes in general do not adequately account for selective attrition.

Prelocation: Locating the same set of respondents in subsequent waves is not a trivial task. Prelocation is the process of locating each respondent and verifying his address before the distribution of the questionnaire in a longitudinal survey. The problem of prelocation was addressed during the 1972-73 consumer survey conducted by the Bureau of Census for the Bureau of Labor Statistics (Walsh, 1977). A considerable part of "loss of information" was attributed to difficulties in locating the respondents. The application of prelocation was found to be successful, even if there was no way to isolate its effect from those of other improvements that were introduced simultaneously in the second year.

These problems as well as the question of conditioning must be considered when updating a questionnaire for subsequent waves. Although it is not possible to eliminate self-selection through an update of the questionnaire, attrition may be minimized by improving the cover letter and instruction sheet, tightening survey administration and possibly by revising the questionnaire itself. While the effect of these measures on attrition is not well known, it is the authors' belief that the administration of the survey is the most critical element in decreasing attrition. However, since administration is the most expensive part of the survey procedure, consideration should be given to the other three remedies as well.

Rizvi (1983) points out that any effort to reduce non-response and attrition demands time and monetary resources. His description of the National Longitudinal Study of the High School Class of 1972 indicates that the following measures were taken to maximize participation and response:

- A series of reminder letters
- Telephone tracing
- Mailgrams
- Monetary incentives ($3 in 1977)
- Additional questionnaires

The response rate in this panel survey was 73.84%. Mailgrams are said to have been most effective, but extremely expensive. It is reported that each subsequent attempt at contact costs more per person than the initial questionnaire mailing. The cost of a contact was found to be as much as 7 times higher than that of the initial mailing (per returned questionnaire).

In addition, the design of a panel survey must take into account the duration of the survey, the frequency of interviews (van de Pol, 1987), and the sampling schemes that are effective in measuring changes. It is likely that optimum values differ from study to study depending on the objectives. Well-practised methods for cross-sectional surveys may not be applicable or adequate in longitudinal surveys. For example, if measuring the rate of change is the objective, then sample size requirements must be determined while considering the population's rate of change. On the other hand, panels (especially rotating panels) may be an economical sampling scheme in some cases.

2.3 Data Processing.

General guidelines to be followed during the data processing stage can be found in the literature (Payne, 1977) and apply to panel surveys as well as cross-sectional studies.

The sequence of steps can be summarized as follows:

1. Analysis of the original data files.

2. Development of a set of computer programs to detect discrepancies and inconsistencies in the data files.

3. Correction of recoverable information using logical checks, and

4. Completion of the rectification procedure by repeating the analysis of the previous steps.

In transportation studies, the resulting data file may be organized into trip-based, person-based and household-based data files for subsequent analysis. The above four-step procedure is applied for the preparation of all three data files.

In panel surveys, a fifth step can be added;

5. Rectify the remaining recoverable information using survey results from subsequent waves.

In addition, information extracted from the first wave data files provides guidelines that are to be followed in updating the questionnaire. The results of this exercise for the telecommuting project are reported in Section 3.3.

3. State of California Telecommuting Pilot Project

The main purpose of the State of California Telecommuting Pilot Project is to assess the utility of telecommuting to the State Government (JALA Associates, 1989). As part of this effort, a panel travel diary was conducted with the intent of evaluating the impacts of telecommuting on household travel. A three-day travel diary was distributed at two different times (1988 to 1989) requesting the participants and driving-

age members of their households to report detailed information on the trips they made on the three survey days. In the first round, the employees who were selected to telecommute had started telecommuting at least once a week. Thus the survey can be considered as a "before and after" study.

The questionnaire used in the first wave was designed by the Transportation, Energy and Air Quality Work Group. The survey questionnaire was distributed and collected by the coordinators of the participating State agencies. The data coding and entry was performed by JALA Associates. This wave of the survey, conducted prior to the introduction of telecommuting, was administered over the period of January to June 1988. The resulting data was analyzed earlier and reported elsewhere (Pendyala, et al., 1989).

The second wave questionnaire was designed by the authors of this paper. Its distribution commenced in April 1989 and ended in July 1989. The survey was again administered entirely by the State agencies. In this wave, the telecommuters were requested to fill out the travel diary on three consecutive weekdays, at least one of which was a telecommuting day (when work was performed at home). The control group did not change their usual work schedule between waves.

3.1 The Survey Sample

The pilot project has involved 222 state employees from 14 agencies. Approximately half of these employees telecommute on an experimental basis. The rest constitute a control group and commute to work conventionally. The latter group is expected to reflect changes in the general travel environment (e.g., changes in gasoline prices) and a comparison between the two groups should allow the isolation of the impact of telecommuting on travel.

Of the original sample of 452 respondents in the wave-1 survey, 364 appeared in the data file containing trip information provided by JALA Associates. Another data file provided by JALA Associates contained personal characteristics on 411 persons in wave-1. Of the 222 employees in this data file, 106 (47.7%) were telecommuters, 88 (39.6%) were control group employees, and 28 (12.6%) were not assigned a definite status. Telecommuter household members numbered 76 while control group household members numbered 93. There were 20 household members unclassified.

In wave-2, a total of 254 individuals responded, of which 149 were employees. There were 77 (52%) telecommuter employees and 55 of their household members. The control group employees who responded numbered 72 (48%), with 50 household members. Information on personal characteristics such as the identity code of the person, agency, and age, was missing or unknown for a few participants in the wave-1 data file. This information was effectively retrieved in wave-2 for the 194 persons who were present in both waves.

Attrition is evident in this panel survey. Of the 222 employees and 189 household members present in wave-1, only 123 employees and 71 household members reported their trips in both waves. These respondents shall be referred to as 'stayers' in this paper. The stayers are made up of 66 telecommuter employees, 39 telecommuter household members, 57 control group employees and 32 control group household members. Those who did not participate in wave-2 include those who did not wish to

return their questionnaire or who returned unusable questionnaires, retirees, and those who left the pilot project because of promotion and other reasons. This group of respondents will be referred to as 'dropouts' in this paper. The additional respondents in wave-2 (60 persons) include new participants, participants who returned unusable questionnaires in wave-1 and those who returned questionnaires only in wave-2 even though they participated in wave-1.

3.2. The Questionnaire and its Evolution

The survey instrument designed for the State of California Telecommuting Pilot Project has undergone changes since it was first distributed in January 1988. The three versions of the first wave questionnaire were distributed in January, March/April and June of 1988. It was updated finally in 1989 to a single unified version which was distributed during the entire second wave.

Updating the first wave questionnaires was an iterative procedure that involved three steps:

1. Identification of the questionnaire items that may have caused inaccurate responses, including questions that are redundant, confusing or not needed at all.

2. With information from step 1, changes to the layout, presentation, wording and contents are made, and the sequence of the questions reordered. In addition to the guidelines identified in the literature review, extreme care was exercised to maintain continuity.

3. The changes made in step 2 are evaluated, and the process is iterated by going back to either step 1 or step 2. The iterative process ended when the desired expected data quality was achieved.

A summary of the changes made to earlier versions of the survey instrument follows:

1. Changes to the Cover: Figure 1a shows the cover page of the travel diary used in the first wave while figure 1b shows that of the second wave. The cover was altered in two ways. First, the diary starting date was entered by the respondent in the wave-2 diary. Second, the color of the cover sheet was unified from a variety of colors to a single color for each group (i.e. white for the telecommuter logs and yellow for the control group). This was done to avoid confusion during distribution of the logs and during data entry.

2. Changes to the First (Yellow) Page: A comparison of figures 2a and 2b indicates the changes made to the first page. This page requests socio-demographic information, household car availability and addresses of frequently visited locations. Changes were made to the layout, wording and order of questions. In addition, two new questions were asked in the wave-2 questionnaire. Participants were asked the gender and employment status of their household members. A retrospective question regarding past employment was introduced.

3. Changes to the (White) Diary Pages: The layout of the diary questions was reorganized into a column-like format and the questions ordered in a manner consistent with the way trip information would be perceived by the respondent.

A question concerning the working status of the respondent on each day of the survey was included. Notice that respondents did not telecommute on every working day even though they were designated as telecommuters. The options for mode choice were augmented with walking, bicycling and car/vanpooling. Boxes were substituted for the line segment previously used to record odometer readings.

In the trip purpose question, the categories were reorganized and changed to achieve completeness and exclusiveness. Some trip purposes were combined to reduce the number of categories (e.g. visit friend/relation and recreation trip purposes were consolidated into one trip purpose labeled social/recreation). Since the question which asked whether the present trip was a continuation of a previous trip was not well understood by the respondents, it was replaced by a trip purpose category called "change mode".

4. General Changes to the Physical Characteristics of the Travel log: The wave-2 diary was bound at the top using a spiral wire, instead of being stapled at the side. This was expected to improve the ease of handling for both the users and the data processors, hence, improving the accuracy of response and the quality of data. In addition, a thick front cover and a chip cardboard back cover were used for durability. The length of the new diary was approximately 1.7 times that of the wave-1 diary, while the thickness and width remained basically the same.

5. Instruction Sheets: In a self-administered survey, respondents need instructions to aid them in filling out the questionnaire properly. Moreover, it is important for the respondents to know the purpose of the survey, the degree of confidentiality of their responses, and the importance of their participation for the success of the survey. Properly formulated instructions enhance response accuracy as well as response rate, since the respondent is more likely to sympathize with the survey when he can appreciate its importance and feel more comfortable with it. A properly formulated instruction sheet or booklet should be clear, brief, and have logically sequenced instructions (according to the order in which the questionnaire is to be filled out).

The formulation and presentation of the instructions for the second wave differ substantially from that of the first wave because of the changes discussed above and the attempt to motivate the respondents to complete their task. The salient characteristics of the second wave instruction sheets were:

- The cover was introduced in order to capture the respondent's attention and to enhance the appearance of the instructions. In this page, a title ("State of California Telecommuting Pilot Project"), the survey starting date, and short introductory instructions for telecommuters were given. Acknowledgement of the respondent's anticipated cooperation was also included at this point.

- The body of the instruction booklet describes the procedural details that respondents should follow in order to ease their task. The

instructions were given in the same order in which the questions appear in the travel diary. Figures were also added with proper guiding labels to avoid any misinterpretation of the questions and the options available. Emphasis was placed on the definition of a trip and the newly introduced trip purpose "change mode".

- At the end of the instruction sheet, directions were written for returning the diary. In addition, a short explanation of the purpose of the survey was included in an attempt to trigger social appeal in the respondents. Finally, and most importantly, examples of completed questionnaires were presented to aid the respondents.

3.3 Data Analysis and Evaluation

The assessment of the effect of the changes in the questionnaire on responses is divided into three segments: attrition, response quality, and trip reporting.

Attrition

A comparison of wave 1 travel characteristics between the participants who responded in both waves (194 interviewees) and those who dropped out in the second wave (170 interviewees) is considered important in evaluating the effect of attrition in our analysis.

It is well known that respondents who remain in both waves of a panel survey are those that are better motivated. Their motivation ranges from the significance to them, of the problem under study, to their lifestyle and values. For example, people commute long distances in heavy traffic would find this survey on telecommuting very interesting and hence would tend to remain in both waves of the survey and report their trips with greater accuracy. On the other hand, persons for whom the commute trip is short may not be so interested in this project. These participants tend to drop-out of the survey after answering in the first wave. It is critical, then, that the travel characteristics of these two groups be examined in order to assess whether the stayers reflect the characteristics of the original sample of 364 respondents in wave-1.

In Table 1, the number of participants who stayed or dropped out in each group is provided. It is seen that 66.7% of the telecommuters remained in both waves while 55.8% of the control group employees remained in both waves. This seems to indicate that telecommuters are more motivated by this study as they are directly affected by the change in work patterns. Similarly, among the household members, it is seen that 55.7% of the telecommuter household members remained in the study, while only 34.4% of the control group household members remained in the study. Attrition is, then, heavily dependent upon group membership.

Table 1 goes here

In Table 2, the average number of trips reported by each group is compared. The telecommuter employees present the smallest difference between stayers and drop-outs. On the other hand, on average, the control employees with fewer trips dropped out of the survey. The same observation can be made of the household members.

Table 2 goes here.

A comparison of the number of trips by purpose is presented in Table 3. Here again we see that the characteristics of the stayers and drop-outs among the telecommuter employees are very similar. The stayers are found to report a marginally higher number of other purpose trips. With regard to the control employees and the telecommuter household members, the stayers are consistently reporting a greater number of trips than the drop-outs. This is indicative of a possible upward bias in the computation of trip rates of the control employees and telecommuter household members of the two groups when the 194 stayers alone are considered. However, the control household members exhibit similar characteristics between their stayers and drop-outs.

Table 3 goes here

A comparison of total distance travelled per day has shown that the drop-outs among the telecommuter employees do not seem to be as mobile as the stayers, travelling 16% less (Kitamura, et al., 1990b). The drop-outs among the other groups also have slightly lower travel distances compared to the stayers. This again, is an indication of the fact that the stayers tend to be persons who feel the impact of travelling long distances.

In addition, an examination of average trip lengths has indicated that the drop-outs tend to have longer trips. Also, the telecommuters show similar work trip lengths between their stayers and drop-outs. However, the stayers among the control group employees and telecommuter household members show shorter work trip lengths.

Overall, the problem of attrition is not pronounced for the telecommuter employees. They have shown quite similar characteristics between their stayers and drop-outs. Hence the characteristics of the 66 stayers could be considered as representative of the characteristics of the 99 original telecommuters who responded in wave 1. However, among the control group employees and telecommuter household members, it is found that the stayers are those who report higher trip rates, but slightly shorter trip lengths.

We cannot evaluate the effect of the enhancements of the questionnaire on the attrition rate. Presumably, the group of respondents common to both waves is the motivated group. Hence, the effect of updating the questionnaire can be evaluated by comparing the quality of the data obtained from this sample. This comparison is presented in the next section.

Data Quality

The data obtained from the first wave (original non-augmented file) presented two major problems to be overcome. First, coding and key punching errors lead to the presence of incorrect data. Second, due to the unclear definition of a trip in the instruction sheets and in the travel diary, respondents tended to enter round trips (consisting of at least two trips) as a single trip.

The results in this section indicate that the second wave responses are of a higher quality than the responses in the first wave. A comparison of the quality of data obtained in the two waves is summarized in Table 4. In wave-1, the 194 stayers reported a total of

2,350 trips in 3 days. In wave-2, these respondents reported a total of 1,953 trips in 3 days (note that the reduction in the total number of trips is in part due to telecommuting). The amount of missing and inconsistent information is compared between the two waves. Inconsistent information refers to data which are not logical (e.g., the ending time of a trip is reported to be before the beginning time of the trip, or the ending odometer reading is reported to be smaller than the beginning odometer reading, etc).

Table 4 goes here.

It was also noticed that non-mechanized trips were often not reported in wave 1. This is due to the lack of mode categories provided specifically for non-mechanized modes of in the wave-1 diary. It is therefore likely that non-mechanized trips were under-reported in wave-1.

While there was a small decrease in response quality in the percentage of freeway travel and the number of passengers, the results indicate an improvement in the quality of the data. It is important to note that this improvement occurred even though a drop in item response across waves due to panel fatigue was expected.

Trip Reporting

Earlier experiences with multi-day travel diaries indicate that the number of trips reported tend to decline toward the end of the diary period (Golob and Meurs, 1986; Meurs, et al., 1989). This is in part due to the increase of days when respondents report no trips at all.

The average number of trips reported in wave 1 decreases toward the end of the diary period (Table 5), suggesting the increasing tendency of trip under-reporting as the survey progresses. The same result can be observed in wave 2, but the tendency is much less pronounced. This may be due to the enhancement of the diary used in this wave. The results suggest that well-formulated questions and neatly designed diaries aid in reducing under-reporting of trips.

Table 5 goes here.

Such improvement, however, cannot be found for the number of non-reporting days, i.e., days on which no trips are reported at all. In the results presented in Table 6 no improvement is evident in non-reporting days. Moreover, telecommuter household members present a somewhat larger number of non-reporting days. In wave-1, one telecommuter household member reported trips only on one day (two non-reporting days) and 6 reported trips on two days. The corresponding numbers for wave-2 are 4 and 6. On the other hand, the control group members do not exhibit any tendencies between the waves (comparison for telecommuters is meaningless because they have started to telecommute in wave 2).

Table 6 goes here

It is possible that the decrease in the number of persons filling out the questionnaires is due to diary fatigue. Diaries require respondents to fill out large amounts of information daily, and when

this is required over more than one day, the effects of fatigue appear to be more pronounced. In this sense, the duration of a diary should be kept to a minimum. A duration of two days may be required in many impact assessment studies. Two day diaries may be more appropriate for these studies because significant decreases in trip reporting were observed on the third day in this study (this, however, may be due to the fact that the third day was the last diary day; also see Pas, 1986).

Even though the use of trip diaries has been recommended (Brog, et al., 1985a; Clarke, et al., 1981) for obtaining accurate information from the respondents, the findings of this study suggest the contrary. The average number of trips reported across the waves has reduced substantially as shown in Table 5. This indicates that the revision of the diary did not aid in reducing panel fatigue in trip reporting. This confirms previous results where a decrease in trip reporting across panel waves was observed (Meurs, et al., 1989).

Overall, it can be seen that trip reporting and item-response can be improved by enhancing the design of the questionnaire and increasing the ease of filling it out. Another aspect deserving emphasis is the importance of effective administration procedures when conducting a panel survey. The respondents should be followed-up at regular intervals during the survey period. Moreover, it would be preferable to have the researchers directly in contact with the respondents, rather than working through intermediaries. Some intermediaries, especially employers and supervisors, may be viewed as having control over employees and this perception may influence their responses. In contrast, researchers, who analyze survey data from neutral viewpoints, would be seen as having no influence on their lives.

4. Conclusions

In this paper, the procedure followed to update a panel survey questionnaire has been presented in detail. The outcome of this exercise has been encouraging as indicated by the reduction in erroneous and missing information. The process of updating a panel survey questionnaire presented in this study is constrained by the need to maintain continuity across waves. Despite limitations thus imposed, it has been shown that improvements made to a panel questionnaire may enhance the quality of information collected. The results, at the same time, indicated that the revision of the diary did not aid in reducing panel fatigue in trip reporting. This remains a challenge. Finally, it is conceivable that the use of a diary may lead to more non-response and attrition because of the time it demands of the respondents. Although experiences reported in the literature support the idea that a diary leads to better trip reporting, its impact on non-response and attrition need to be carefully examined, especially for multi-day diaries.

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The contents of this paper reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This paper does not constitute a standard, specification or regulation.

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Table 1

Number of Wave-1 Participants by Group

	Employees		Household Members		
	Telecom.	Control	Telecom.	Control	Total
Stayers	66	57	39	32	194
Dropouts	33	45	31	61	170
Atr.Rate (%)	33	44	44	66	47

Atr. Rate = Attrition rate in percentage

Table 2

Number of Wave-1 Total Trips per Day by Group

	Employees		Household Members		
	Telecom.	Control	Telecom.	Control	Weighted Average
Stayers	3.90	4.39	4.27	3.42	4.04
Dropouts	3.88	3.32	2.96	3.06	3.27
Difference	-0.02	-1.07	-1.31	-0.36	-0.77

Table 3

Number of Wave-1 Trips per Day by Purpose

		Employees		Household Members		Weighted
		Telecom.	Control	Telecom.	Control	Average
Work	Stayers	1.11	1.14	0.88	0.72	1.01
	Dropouts	1.22	0.97	0.57	0.69	0.84
Difference		0.11	-0.17	-0.31	-0.03	-0.17
Home	Stayers	1.23	1.32	1.13	1.05	1.21
	Dropouts	1.38	1.06	1.16	1.06	1.14
Difference		0.15	-0.26	0.03	0.01	-0.07
Other	Stayers	1.57	1.91	2.25	1.65	1.82
	Dropouts	1.28	1.28	1.22	1.31	1.28
Difference		-0.29	-0.63	-1.03	-0.34	-0.54

Table 4

Comparison of Missing and Inconsistent Information Between Waves for Selected Trip Characteristics

	Wave 1		Wave 2	
Number of Trips	2350		1953	
Origin Base	24	(1.0%)	16	(0.8%)
Destination Base	41	(1.7%)	25	(1.3%)
Reported Trip Length	127	(5.4%)	25	(1.3%)
Trip Duration	91	(3.9%)	64	(3.2%)
Trip Purpose	56	(2.4%)	30	(1.5%)
Odometer Readings	457	(19.4%)	294	(15.0%)

Table 5

Trips Reported by Day

			Day 1 a	Day 2 b	Day 3 c	a-b	a-c	b-c
Employees								
T/C	Wave 1	(63)	4.00	4.14	3.59	-0.14	0.41	0.56
	Wave 2	(60)	3.23	3.25	2.62	-0.02	0.62	0.63[a]
Control	Wave 1	(50)	4.56	4.34	4.10	0.22	0.46	0.24
	Wave 2	(47)	3.96	4.11	3.85	-0.15	0.11	0.26
Household Members								
T/C	Wave 1	(39)	4.59	3.64	4.54	0.95[a]	0.05	-0.90
	Wave 2	(34)	3.35	3.24	2.68	0.12	0.68	0.56
Control	Wave 1	(32)	4.63	3.06	2.56	1.56[a]	2.06[a]	0.50
	Wave 2	(26)	3.50	3.54	3.42	-0.04	0.08	0.12
Average	Wave 1	(184)	4.39	3.90	3.75	0.48[a]	0.64[a]	0.15
	Wave 2	(167)	3.50	3.53	3.10	-0.03	0.40	0.43[a]

T/C = Telecommuters
Control = Control Group Members
[a]significant at the 5% level

Table 6

Number of Respondents by Trip Non-Reporting Days

			No. of Non-Reporting Days			
			0	1	2	Total
Employees	T/C	Wave 1	59	2	2	63
		Wave 2	42	12	6	60
	Control	Wave 1	47	3	0	50
		Wave 2	46	1	0	47
Household Members	T/C	Wave 1	32	6	1	39
		Wave 2	24	6	4	34
	Control	Wave 1	26	4	2	32
		Wave 2	20	3	3	26

T/C = Telecommuters
Control = Control Group Members

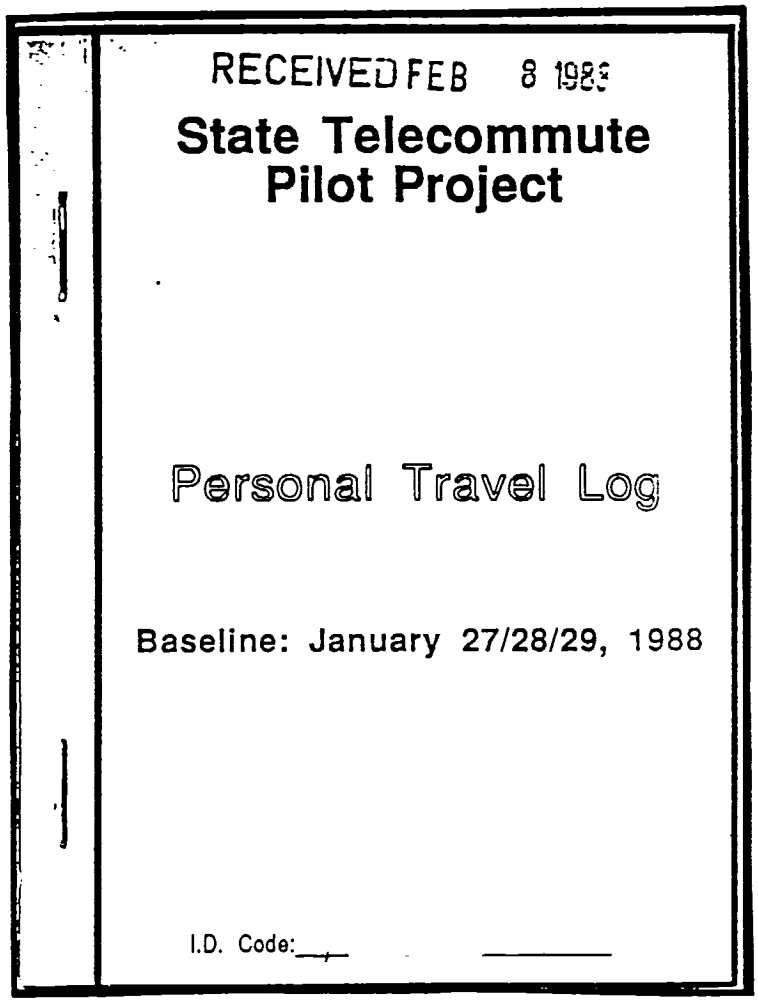

RECEIVED FEB 8 1989
State Telecommute
Pilot Project
Personal Travel Log
Baseline: January 27/28/29, 1988
I.D. Code:

Fig. 1a

Cover

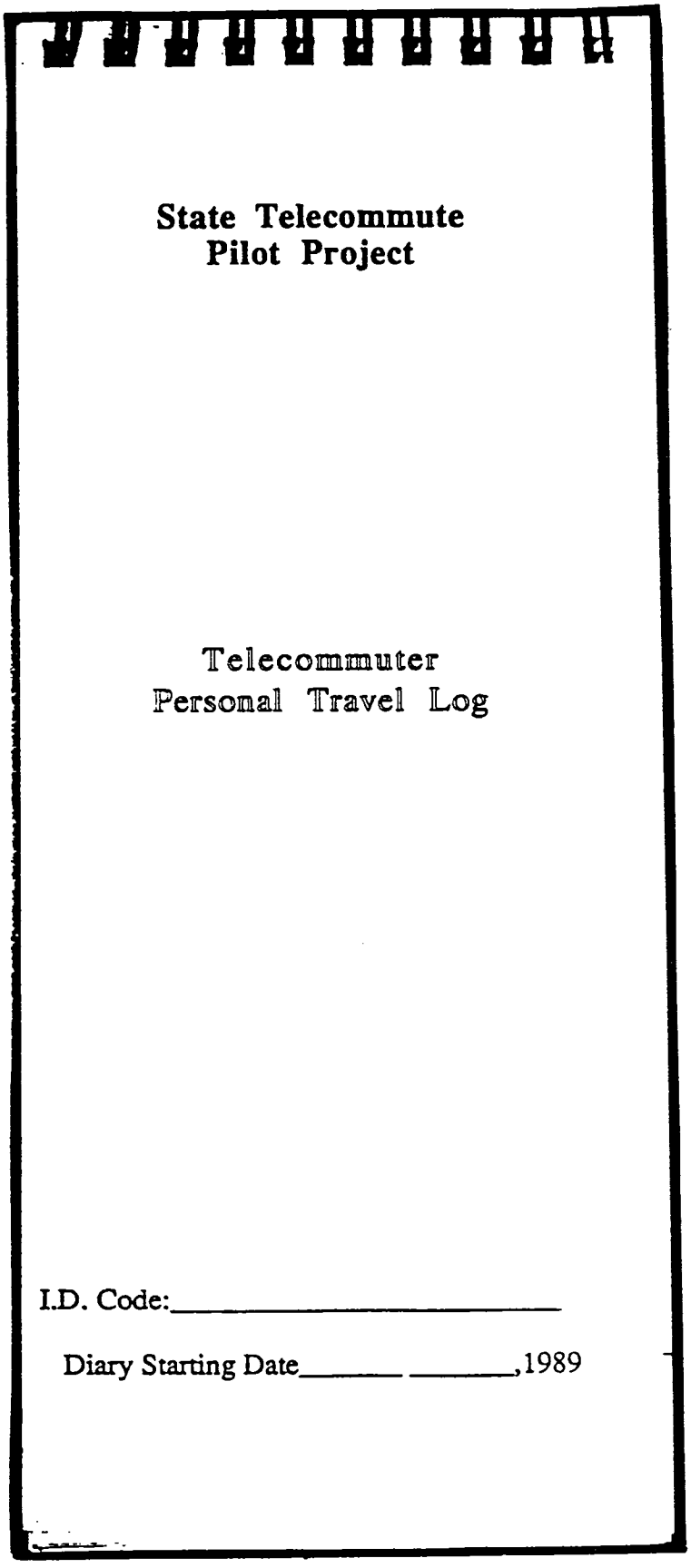
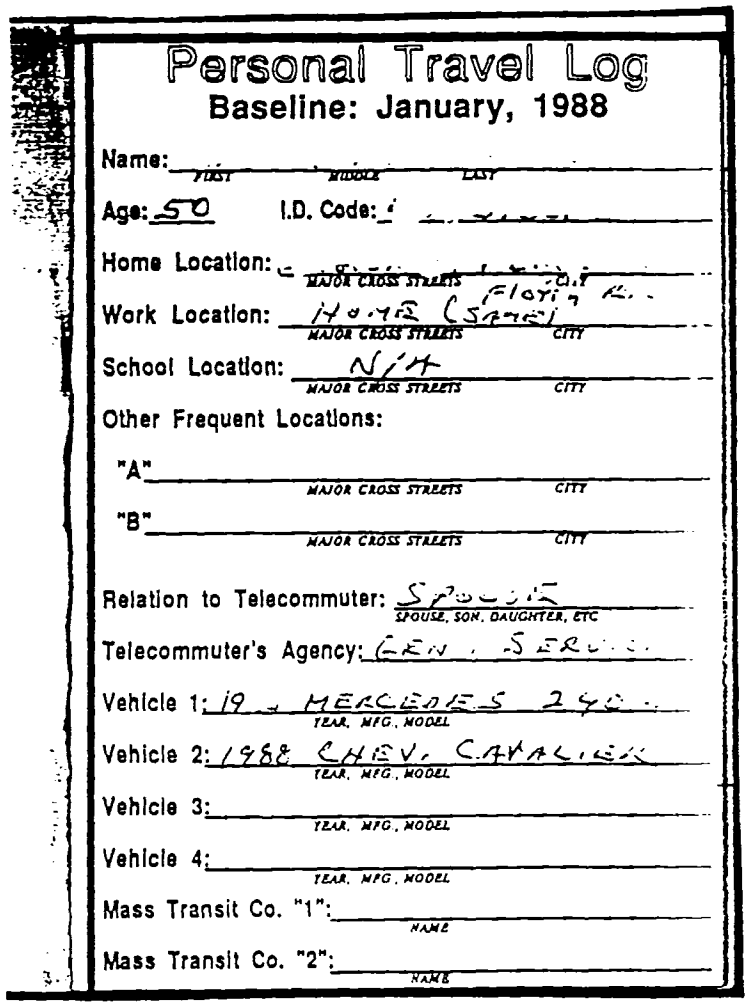

State Telecommute
Pilot Project
Telecommuter
Personal Travel Log
I.D. Code:_____
Diary Starting Date_____ _____,1989

Fig. 1b

Cover



Personal Travel Log

Baseline: January, 1988

Name: _____ (FIRST, MIDDLE, LAST)

Age: 50 I.D. Code: [illegible]

Home Location: [illegible] (MAJOR CROSS STREETS) Florida (CITY)

Work Location: [illegible] (MAJOR CROSS STREETS) [illegible] (CITY)

School Location: N/A (MAJOR CROSS STREETS) (CITY)

Other Frequent Locations:

"A" _____ (MAJOR CROSS STREETS) (CITY)

"B" _____ (MAJOR CROSS STREETS) (CITY)

Relation to Telecommuter: Spouse (SPOUSE, SON, DAUGHTER, ETC)

Telecommuter's Agency: GEN. SERV.

Vehicle 1: 19 - MERCEDES 240 (YEAR, MFG., MODEL)

Vehicle 2: 1988 CHEV. CAVALIER (YEAR, MFG., MODEL)

Vehicle 3: _____ (YEAR, MFG., MODEL)

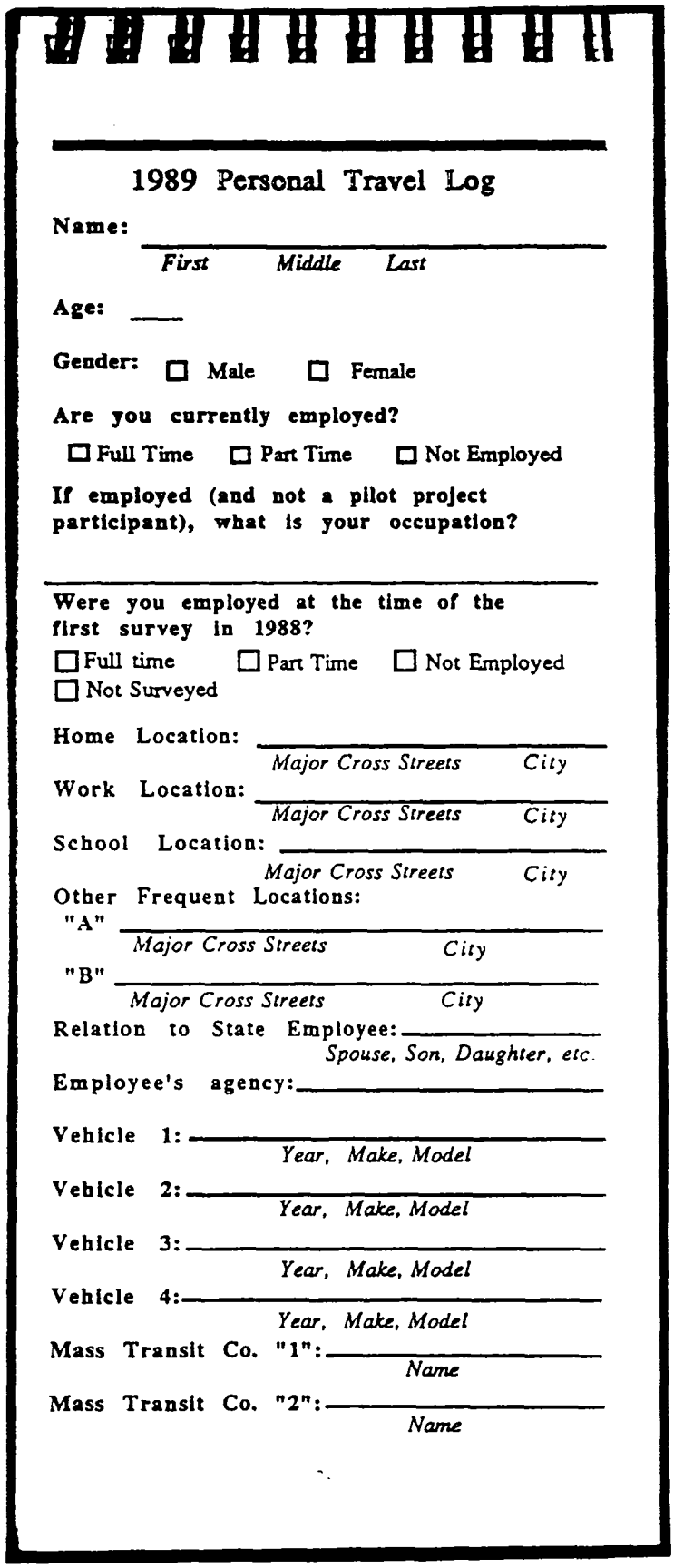
Vehicle 4: _____ (YEAR, MFG., MODEL)

Mass Transit Co. "1": _____ (NAME)

Mass Transit Co. "2": _____ (NAME)

Fig. 2a

First Page



1989 Personal Travel Log

Name: _____
First Middle Last

Age: ____

Gender: ☐ Male ☐ Female

Are you currently employed?

☐ Full Time ☐ Part Time ☐ Not Employed

If employed (and not a pilot project participant), what is your occupation?

_____

Were you employed at the time of the first survey in 1988?

☐ Full time ☐ Part Time ☐ Not Employed
☐ Not Surveyed

Home Location: _____
Major Cross Streets City

Work Location: _____
Major Cross Streets City

School Location: _____
Major Cross Streets City

Other Frequent Locations:

"A" _____
Major Cross Streets City

"B" _____
Major Cross Streets City

Relation to State Employee: _____
Spouse, Son, Daughter, etc.

Employee's agency: _____

Vehicle 1: _____
Year, Make, Model

Vehicle 2: _____
Year, Make, Model

Vehicle 3: _____
Year, Make, Model

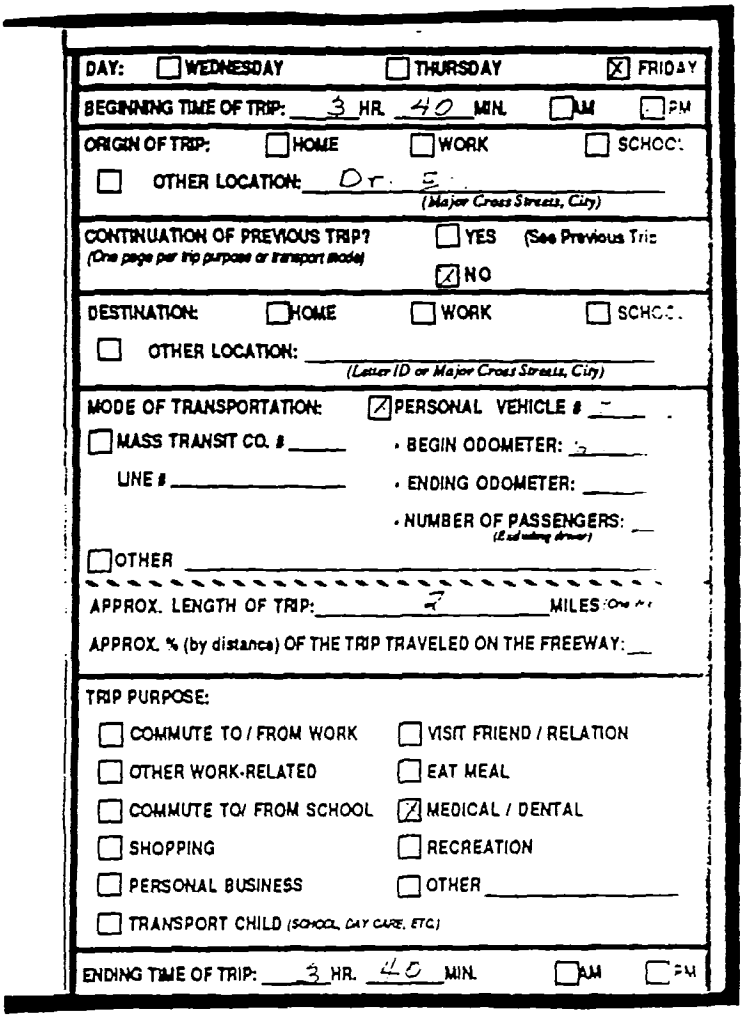
Vehicle 4: _____
Year, Make, Model

Mass Transit Co. "1": _____
Name

Mass Transit Co. "2": _____
Name

Fig. 2b

First Page



DAY: ☐ WEDNESDAY ☐ THURSDAY ☒ FRIDAY

BEGINNING TIME OF TRIP: 3 HR. 40 MIN. ☐ AM ☐ PM

ORIGIN OF TRIP: ☐ HOME ☐ WORK ☐ SCHOOL

☐ OTHER LOCATION: Dr. S (Major Cross Streets, City)

CONTINUATION OF PREVIOUS TRIP? (One page per trip purpose or transport mode) ☐ YES (See Previous Trip) ☒ NO

DESTINATION: ☐ HOME ☐ WORK ☐ SCHOOL

☐ OTHER LOCATION: _____ (Letter ID or Major Cross Streets, City)

MODE OF TRANSPORTATION: ☒ PERSONAL VEHICLE # _

☐ MASS TRANSIT CO. # _____ • BEGIN ODOMETER: _____

LINE # _____ • ENDING ODOMETER: _____

• NUMBER OF PASSENGERS: _ (Excluding driver)

☐ OTHER _____

APPROX. LENGTH OF TRIP: 7 MILES (One Way)

APPROX. % (by distance) OF THE TRIP TRAVELED ON THE FREEWAY: __

TRIP PURPOSE:

☐ COMMUTE TO / FROM WORK	☐ VISIT FRIEND / RELATION
☐ OTHER WORK-RELATED	☐ EAT MEAL
☐ COMMUTE TO/ FROM SCHOOL	☒ MEDICAL / DENTAL
☐ SHOPPING	☐ RECREATION
☐ PERSONAL BUSINESS	☐ OTHER _____
☐ TRANSPORT CHILD (SCHOOL, DAY CARE, ETC)	

ENDING TIME OF TRIP: 3 HR. 40 MIN. ☐ AM ☐ PM

Fig. 3a

Travel Log

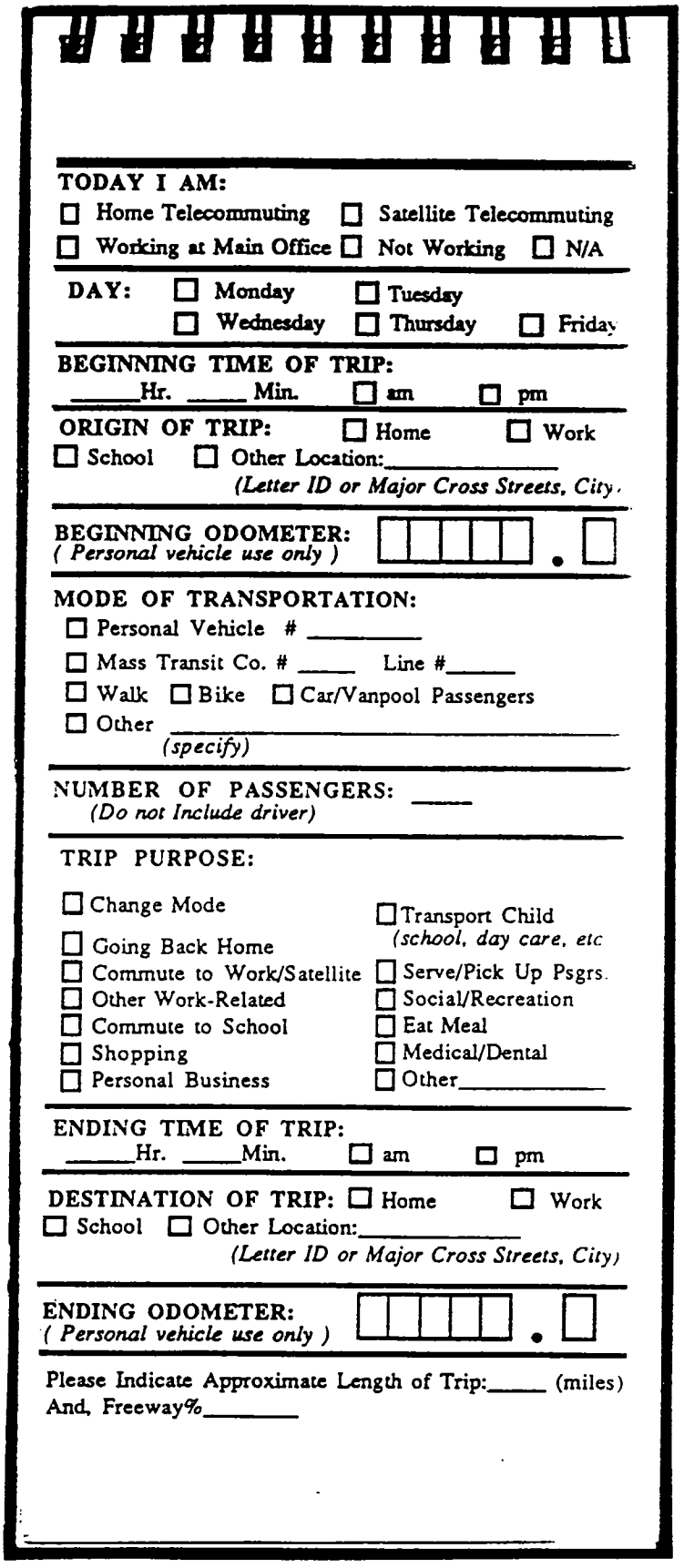


Fig. 3b

Travel Log