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1981 San Francisco Bay Area Travel Survey

MARILYN M. REYNOLDS, SYDWELL M. FLYNN, AND DAVID B. REINKE

Household travel data constitute a major cornerstone of regional transportation planning analysis. But many household travel data sets in use today are more than 10 years old, and cost considerations have deterred many areas from updating these data. The planning, design, and conduct of a householdinterview travel survey in the San Francisco Bay Area in the spring of 1981 are described. Household and travel information was collected by telephone from 7200 households in the nine-county jurisdiction of the Metropolitan Transportation Commission. Telephone interviewing proved to be a cost-effective method for conducting household interviews. The sample gave good geographic coverage and provided a good representation of the population groups in the Bay Area.

One of the most difficult and costly factors in transportation decisionmaking is the collection of data on which to base analyses. Because of this cost, it is often tempting to skip a rigorous analysis and to rely on "back-of-the-envelope" calculations. The fact that large-scale decisions often appear to be made on a political rather than an analytical basis contributes to this view.

However, the argument can be made that a solid analysis is necessary no matter what other considerations enter into the decision $(\underline{1})$; it is this view that motivates us to undertake data-collection projects.

Many planning agencies are asking whether a complicated household-interview travel survey can be accomplished within today's severe fiscal constraints. Is it possible to obtain a large enough sample to make the survey worthwhile? Can a survey of this type be conducted and processed in a reasonable time? Will the public participate willingly? Can a survey achieve representative sampling of all population groups?

This paper describes the planning, design, and conduct of a household travel survey in the San Francisco Bay Area in the spring of 1981 and discusses how well the survey attained its goals.

BACKGROUND

In the early 1960s in the San Francisco Bay Area, there was a rising interest in transportation matters. The Bay Area Rapid Transit (BART) system was being designed, an additional bridge across the Bay was contemplated, and highway projects of many kinds were in the planning stages.

The Bay Area Transportation Study Commission (BATSC) was formed to create a transportation plan for the region. One of its major projects was a huge travel survey. The BATSC survey gained a certain amount of fame (or notoriety) because of several reasons: its size (home interview of 30 000 households), its cost (more than \$1.5 million for data collection), and its failure to achieve a random sample due to lack of coverage of certain minor-

ity neighborhoods. Among data processing people, it gained a nightmare reputation because all processing was done on second-generation systems with sequential tape storage only.

In 1970, the California Legislature created a metropolitan planning organization for the San Francisco Bay Region: the Metropolitan Transportation Commission (MTC). Since its creation, MTC has collected and used many types of transportation data. However, the backbone of its transportation data base has been the BATSC survey. The 1970 Census journey-to-work data set proved to be almost unusable because of insufficiently coded work locations. Only after the poorly coded trip ends were assigned, by using the 1965 BATSC data as a template, was this census data set of any value.

It is hoped that the 1980 Census journey-to-work data will be much better. Nevertheless, the world has changed a great deal between 1970 and 1980, and work-trip information alone will not suffice.

Decisions to invest in large capital projects and accompanying long-range planning efforts are conspicuously absent in 1981. Because of fiscal constraints and a change in philosophy, the shift has been to better management and deployment of the existing system. This strategy, sometimes called transportation system management, calls for looking at smaller parts of the system and devising ways to improve them. Accompanying these changes, there has been a strong upward trend in transit use in the San Francisco Bay Area. As always, transit's limited resources must be used to maximize service to the public.

Several other major transportation changes have occurred in the area in the past decade. Some of these were direct: for example, the start-up and operation of the BART system and the emergence of new bus systems in several suburban counties. Others were economic and demographic: the apparent disappearance of the stay-at-home housewife and the massive entry of mothers into the work force, the increase in automobile ownership, the rise in the cost of owning and operating a car, and the greatly expanded number of unrelated-adult households.

What data are needed to do the best job of making the transportation system work for the people of the region in the 1980s and beyond? While other types of data are often useful for analyses, specific household-interview transportation survey data are occasionally necessary (2). For example, in deciding how best to alleviate congestion on a bridge, it is not enough to count the vehicles on the bridge (how many) or even to do a postcard or license-plate survey of such travelers (who, why, where). One must separate the unavoidable single-occupancy trips from the others and analyze strategies to maximize behavior change where possible. The information needed for this analysis is the description of trips made by individuals during the entire day, available only from a household-interview survey. It was decided that the best method to secure these data was to conduct a survey of Bay Area households.

At this time, the San Francisco Municipal Railway (Muni) was planning to conduct a latent demand survey. The intent was to determine the travel patterns of San Francisco residents in order to better serve them by changes in routes, schedules, and levels of service within San Francisco. The data needed were essentially the same as those required by MTC:

 Household data--Housing, number of persons, vehicles, and income;

 Person data--Demographics, ethnicity, mobility, employment, and work address; and

3. Trip data--Origin and destination (address, purpose, time), mode, automobile detail, and transit detail.

MTC and Muni agreed to pool their funds for a travel survey to be conducted in the spring of 1981. To satisfy Muni's needs, a higher proportion of San Francisco households would be interviewed because of the higher sampling frequency requirement imposed by the more local geography of transit routing needs.

PLANNING THE SURVEY

The question, "What sample size is really needed?" was asked repeatedly. The answer, "All we can get," was taken to be facetious; but, in fact, it was accurate. Because of the multivariate nature of the data and the need for a useful origin-destination matrix, the simple methods of relating sample size to required precision did not apply. On the contrary, to obtain a valid origin-destination matrix for the 440-zone system used by MTC, more than 60 000 household samples would have been necessary, at a cost of \$3 million or more. The available funds were \$200 000 from MTC and \$160 000 from the Muni latent demand study. At an estimated \$50/ household, this was expected to produce a sample of about 7200 households.

One of the important considerations in planning for this survey was to avoid or overcome the problems that plagued the 1965 BATSC survey. Some of these were

 Underrepresentation of certain neighborhoods and ethnic groups,

2. Slowness of field work and coding,

3. Excessive cost, and

4. Data reduction problems.

Some of these were solved by technical advances in the 16 years since BATSC: Data processing hardware had evolved from tape to disk, and efficient data management software was now available. Other problems, such as the slowness and the cost, were solved in part by a smaller sample size; in addition, the decision to use a professional organization for the field work rather than an in-house effort speeded up the process.

The remaining problem that needed to be addressed, that of uneven representation, was dealt with in the design, sampling, and field operations.

SURVEY DESIGN

Sample Selection

Two methods were considered for selecting the sample

for a telephone survey: address-based sampling from the reverse telephone directory and random digit dialing.

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Address-based sampling has the advantage that the geographic distribution of the sample can be controlled precisely. Furthermore, households in the sample can first be contacted by mail. This helps to establish the legitimacy of the survey and could therefore result in a lower refusal rate than if the households were first contacted by telephone.

This method has the disadvantage that households with unlisted addresses or unlisted telephone numbers would be excluded from the sample. As was found at the end of the survey, this would have resulted in a bias against households with the following characteristics: apartment dwellers, shorter length of residence at the current address, and low automobile ownership. It was also suspected that these households contained a higher proportion of households headed by females.

Random digit dialing can overcome these problems but has disadvantages of its own. Households must first be contacted by telephone and may therefore be more reluctant to participate in the survey. Geographic distribution of the sample cannot be precisely controlled. Pure random digit dialing can be a very inefficient procedure if some way is not found to reduce the chance of reaching unused or nonresidential numbers.

The sample for this survey was drawn by using directory-based random digit dialing. For each number drawn from the directory, one was added to it; e.g., if the number from the directory was 849-3223, the number to be dialed was 849-3224. If the number was not a working residential number, a new number was generated by again adding one to the number; this procedure was repeated until a working residential number was reached. This procedure has the advantage that the possibility of generating duplicate telephone numbers in the sample was minimized. Furthermore, because Pacific Telephone has no systematic method of assigning unlisted numbers, this method could be expected to have no systematic bias against households with unlisted numbers.

Geographic distribution of the sample was monitored throughout the survey. MTC had asked that the sample contain at least one household in each travel analysis zone with a significant population. If some zones were found to be underrepresented in the sample, additional households would be drawn from these zones by using the address listings in the reverse telephone directory. The number of households expected to be drawn this way--and, therefore, the expected bias introduced into the sample--was deemed insignificant. In fact, it was found that it was not necessary to draw a further sample from the reverse directory.

The sample was to consist of 7000 households. Half of these were to be in San Francisco; the remaining 3500 households in the sample were allocated to the other eight counties in proportion to the number of dwelling units in each county. Dwellingunit counts from the 1980 Census were used to make these allocations.

The sample was primarily intended to measure weekday travel; the size of the weekend travel sample was sufficient to enable MTC to make inferences about weekend trip generation. Travel days in the sample were spread out evenly over the three-month interviewing period to eliminate seasonal bias. Although it would have been more efficient to interview households in one county at a time, such a procedure would have biased the sample because of changes in weather or other special incidents over the March-May period.

Figure 1. Interviewing procedure.



Interviewing Plan

A two-part interviewing procedure was used to reduce the length of each telephone contact to 5-20 min. A preliminary interview gathered household socioeconomic information; a second travel interview gathered information on the number and the type of trips made on a given travel day by each household member.

The initial contact with sampled households was made by telephone. Each household was called at least two times (afternoon and evening) on three weekdays and Saturday--a total of eight calls-before the household was considered unreachable and another number substituted. The sequence of events for the interviewing is shown in Figure 1.

Once a household was contacted, the interviewer gave a brief introduction regarding the survey's purpose and then completed the nontravel questions. The interviewer next explained that during the second step of the survey each member of the household would receive a travel card, by mail, on which to record all trips he or she made on the household's assigned travel day. The interviewer obtained a commitment from a household to fill in the travel card and made an appointment to call back to gather this travel day. The preliminary interview took an average of 8 min to complete.

The travel cards (see Figure 2) and a covering letter that served to authenticate the survey were then mailed to the household. The purpose of the travel cards was to serve as a reminder of the key features of each trip (origin, destination, purpose, time, etc.).

Figure 2. Travel card.

1981 MTC AREA TRANSPORTATION STUDY YOUR TRIP RECORD FOR ONE DAY

				I ravel L)ay
From		То		-	0
Start Time	Place	Place	Arr. Time	Mode	Fare
_		-			
	-				

The household was called a second time the day following the assigned travel day to record information on the number and type of trips taken by each household member. Whenever possible, each household member was interviewed individually about the trips he or she had made; however, if some persons were not available or were young children, the interviewer took the information recorded on their travel card from another responsible adult. Average time to complete the travel interview with all household members was 30 min. If on this call-back the household members indicated that they had forgotten to fill in their travel cards, had not received the travel cards in the mail, or had lost their cards, they were asked if they could recall their trips from the previous day without benefit of the cards. (Questions such as, And where did you go next? Did you stop anywhere along the way? were asked by the interviewer to ensure that trips were not overlooked or forgotten.) If they preferred, a substitute travel day was assigned for the following week and,

if necessary, another set of travel cards was mailed to the household. Each household was called at least two times (afternoon and evening) on four successive days following the assigned travel day--a total of eight calls--before it was considered unreachable.

Interviews were conducted from three different Bay Area locations each weekday between 1:00 and 9:00 p.m. and on Saturday between 10:00 a.m. and 4:00 p.m. The three offices were staffed by fewer interviewers from 1:00 to 5:00 p.m., when many households are unreachable by telephone, and with a full staff of interviewers from 5:00 to 9:00 p.m. and all day on Saturday.

When a telephone number was selected as part of the survey sample, it was recorded on the call control sheet. Each of these sheets was then stamped in the upper left corner with a day of the week that became the assigned travel day for the interviewed household. To ensure that the correct number of households was interviewed for each day of the week, the assigned travel day for a household could not be changed.

FIELD PROCEDURES

Preparation

Pretest

The pretest was conducted over a two-week period; the results confirmed the workability of the interviewing method and the survey design. The response of the majority of those who did participate was encouraging: They perceived the survey as important since transportation was an issue that directly affected their lives.

Hiring and Training of Interviewers and Coders

Interviewers

Potential interviewers who responded to an advertisement placed in regional and local papers were screened on the telephone, interviewed by the survey supervisor, and given a 30-min proficiency test of ability to deal with and record detailed data, a skill much required by the survey.

Three training sessions were conducted to instruct interviewers. Only preliminary interviews were conducted the first week of the survey. This allowed the interviewers to perfect their skills for this portion of the survey before starting on the travel interview. Before the second week of survey operations, interviewers were paired and asked to conduct the travel interview by questioning each other about the actual trips they had made on that or the previous day. Once interviewers felt comfortable with this new part of the survey, they began the regular telephone interviews.

Group discussion meetings were held regularly, both on a scheduled and a spontaneous basis throughout the project period. During these sessions, supervisors and interviewers addressed common problems and passed on success tips based on individual experience.

Coders

A separate training session was conducted for the coders. An overview of the purpose and procedures of the survey was presented since it was important to their task that the coders have an understanding of how and why the survey was being conducted. Coding instructions were thoroughly reviewed. Each person coded a sample guestionnaire that was designed to pose questions and difficulties that coders were likely to encounter once coding of actual questionnaires began. Coding instruction continued for the first several weeks of the survey. Coding supervisors were available at all times to assist with problems or questions.

Publicity

One week prior to the start of survey operations, MTC sent a news release to 364 Bay Area newspapers and television and radio stations. The newspapers included major publications that reach all Bay Area counties and more local publications. Small articles describing the forthcoming survey did appear in about 10 local publications. Radio stations KAML and KGO interviewed the MTC project director about the survey purpose and procedure; they presumably aired this brief interview for their listeners.

Overall, however, publicity efforts were not successful in reaching the general public. The news release was not picked up by any of the large regional newspapers, nor were public service announcements regarding the survey aired on major radio or television stations. Thus, most people were not aware of the survey unless their household was contacted by telephone.

Interviewing

Operations

Each day, interviewers were given a stack of call control sheets on which sampled phone numbers had been recorded. When an interviewer contacted a household and completed the preliminary interview, the call control sheet was stapled to the top of the questionnaire. These questionnaires were then edited for accuracy and completeness, and a notation was made on the questionnaire if additional data or corrections were required. Edited questionnaires were then placed in groups according to when the household was to be called back for the travel interview. During this second interview, survey workers corrected any problems indicated by the editors. Once the travel data for each household member were obtained, these travel sheets were stapled to the previous pages and once again delivered to editors for their checks. If information was missing or appeared ambiguous, the questionnaire was returned to the interviewer, who cleared up ambiguities or again called the household to obtain the missing data.

Productivity

The number of paid interviewer hours per week was compared with the number of interviews completed each week to determine productivity--that is, the amount of time required to produce a completed, edited questionnaire. In the first two weeks of the survey, approximately 2 h was required to complete a questionnaire; by the end of four weeks, this had decreased to 1.7 h. By the sixth week, the time per questionnaire had evened out to 1.5 h and remained such throughout the remainder of the survey.

The increase in productivity was due mainly to three causes:

1. Interviewers became increasingly efficient as their familiarity with the questionnaire developed. They could anticipate respondents' sources of anxiety about participation and also comfortably address these issues. The interviewers' growing familiarity with the geography, landmarks, and transit systems of the survey project area influenced their smoothness in obtaining the data and the efficiency of their probing.

2. During the first month of survey operations, call-backs were made to households that had refused to participate. After the first month, these procedures were eliminated because they were not cost effective.

3. Changes in procedures for recording transit trips resulted in less information being required from the respondent for beginning and ending times and locations at transfer points.

Problems

Four major problem areas surfaced during survey operations. These problems and the methods used to deal with them are discussed below.

Obtaining and Maintaining Participation of Respondents

The pretest had produced a 32 percent refusal rate. The goal was to lower this ratio in the actual survey, although we were aware of the public's changing attitude toward surveys. Many people are cynical about government in general and about giving out personal information to government agencies. The increasing crime rate has also made people more wary about revealing information of a personal nature. Households with unlisted telephone numbers are sensitive to what they consider an invasion of their privacy. In some cases, the explanatory covering letter and travel cards that were mailed to households after the preliminary interview were not received, which led them to question the legitimacy of the survey.

Several procedures were used to deal with the above problems. First, interviewers were directed to be completely open with respondents by answering any questions they might pose about the sponsor, purpose, or validity of the survey. The training session included a period of role playing during which interviewers had to respond to hypothetical inquiries of fearful, suspicious, hostile, or simply curious respondents.

Persons who questioned the validity of the survey were offered MTC's telephone number and the suggestion to call and speak with the MTC project director. The survey supervisor's name and number were also offered. When persons with unlisted numbers demanded to know how their number had been obtained, we explained that it had been randomly generated by a computer. The interviewers openly acknowledged that this procedure was used to reach unlisted households, which constitute up to 40 percent of urban households, and explained, "If we missed all such households, our results would be invalid." In most instances this honest, straightforward explanation worked and the household agreed to participate; others, however, remained adamant and would not participate.

When respondents refused to divulge their home address (information critical for analysis purposes), the interviewer offered to mail the cards to a work address or a post office box. Other households were asked or volunteered to keep track of their trips without benefit of travel cards. Interviewers proposed or accepted this option only if the respondent agreed to provide sufficient information to allow his or her place of residence to be located within a census tract (e.g., his or her street and the nearest cross street) while still withholding information on actual address. However, in spite of these offered alternatives, some households were adamant in their refusal to provide any information that would locate their residence.

Finally, when household members said they had not

received the mailing, we offered to mail the letter and cards a second time and rescheduled their travel day for the following week.

Lack of Communication Within Households

Communication between household members was often a problem, particularly within households that contained numerous unrelated adults with diverse schedules. The person contacted on the preliminary interview often forgot to tell his or her housemates about the survey, or their diverse schedules allowed little contact among household members. A second problem was that, although some household members were willing to participate, a clear understanding of other members' attitudes was sometimes not available. Travel-day interviews sometimes dragged on more than a week while interviewers attempted to contact one or two unreachable household members. If evasion could be clearly construed as a refusal, the situation was easier to handle; unfortunately, this was often impossible to determine.

These problems were much less prevalent among family households, in which there was better communication among family members and the level of cooperation tended to be similar--i.e., if the wife/ mother agreed to participate, her husband and children would also participate. In addition, family members were much more knowledgeable about the trip patterns, work location, car ownership, etc., of other family members, whereas housemates often share only living quarters and know little about their roommates' lives.

Recording Transit Trips

Recording public transit trips, especially if a respondent's day involved many linked trips, was time consuming and often irritating to the respondent. Interviewers were instructed to record locations and begin and end times for all points on an individual trip. During the third week of the survey, this procedure was modified. Exact locations and times were recorded only for the beginning and ending locations of the trip. Locations of intermediate points--i.e., bus stops where the trip purpose was "change travel mode"--were omitted; only the total walk time from one's home to the bus stop or between buses was recorded. These changes greatly streamlined the recording of transit trips and contributed to a more pleasant interaction between interviewers and respondents.

Scheduling Preliminary and Travel Interviews

Correct adherence to the two-phase interview contact formula in order to end up with a sample that met survey requirements was a challenge. The survey design required that each household be contacted for the preliminary interview at least four days before the assigned travel day in order to allow for timely mail delivery of travel cards and instructions. At the same time, it was believed that households contacted too far in advance of their travel day would be apt to forget their commitment to participate or misplace their travel cards. Another requirement was to conduct about the same number of preliminary interviews each day in order to produce an even number of travel interviews for each day of the following week. These requirements demanded that the supervisors constantly monitor the conduct of preliminary interviews to achieve an even production rate by day of week and monitor travel-day interviews to ensure that households were called at their scheduled time and that required call-backs were made.

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A common problem experienced by all interviewers was the difficulty in obtaining exact addresses for trip locations. Although the respondent might be traveling to a familiar spot, he or she would often be unaware of the address or the nearest cross street, information that was required to locate the destination within a census tract. If the respondent was not the driver or the route taken was not a common one, the problem was intensified and a "best guess" served. Trips that took the respondent out of the Bay Area (via ground transportation) were also a problem because it was sometimes difficult to determine at what point the respondent left the Bay Area.

If more than two or three days had passed between the travel day and the interview, respondents occasionally experienced some difficulty with recall. Even those who had filled in their travel cards as reminders might not remember the specific address or the cross streets of a destination because the travel cards asked only that the respondent note the "place" and did not specify the need for an exact location. The use of "address or intersecting street", and possibly an example, would have been clearer.

Respondents who regularly traveled in the Bay Area as a part of their job were understandably reluctant to trace every detailed portion of their workday. Some flexibility was required in such cases or many more of these truck drivers, delivery persons, and salespersons would have been lost to the study.

Coding and Data Processing

Coding and Manual Checking Procedures

The coders were responsible for coding any items not previously entered on the guestionnaires by the interviewers or editors. Coders were also to review forms for legibility and completeness. The most important and time-consuming portion of the coders' job was to convert all home and work addresses and all trip origins and destinations into census tract numbers. This could be quick for a specific address on a well-known street but time consuming for a vague address.

Each coded questionnaire was then spot checked for completeness and accuracy. If more than two errors were found on a questionnaire, it was completely checked and corrected.

Coding productivity improved steadily during the survey. During the first weeks, a completed questionnaire took an average of 70 min to code and manually check; by the end of the survey, this had dropped to 35 min.

Most of the increase in coder productivity came about because coders worked faster as they became more familiar with the contents of the questionnaire and with locations around the Bay Area. The change in interview procedures for recording transit trips also reduced coding time significantly.

Coding Problems

During the survey, there was continual discussion between coding and interviewing supervisors. When coders encountered problems with incomplete data on the questionnaire, the coding supervisors informed the interviewing supervisors about the problems and suggested ways to avoid further occurrences. Most of these problems were resolved during the first two weeks of coding.

The biggest coding problem throughout the survey

was incomplete or inaccurate information on locations; e.g., an address was given that did not exist, a given street intersection was actually two parallel streets, or a street intersection or block on the border of two or more census tracts was given. When these problems occurred, households were contacted again by interviewers or coding supervisors to try to get more complete information. If the information was still too vague, a census tract was not coded. In some cases, a census tract in the middle of the city or street was coded or a random number was generated manually (a die was thrown) and was used to select one of the possible tracts.

Data Processing

The data returned from keypunch were kept in three separate files:

File	Data Form	No. of Records
Household	Housing Unit Summary	One per household
Person	Occupants of Housing Unit	One per person
Trip	Trip Report	One per unlinked
		trip

Several types of checks were made by computer on the data. Individual data were checked for proper range and format; data in different files were cross checked for consistency. The data were also checked to ensure that there was at least one record in each of the three files for each household and that duplicate records did not appear in each file.

An interactive computer system, WYLBUR, was used to edit the data; this was more cost effective than having individual items keypunched again and merged back into the files. Most of the errors that were detected could be resolved by the data checker. But some errors, such as missing census tract information, could not be resolved; in these instances, the data had to be left missing. There was no consistent pattern to the types of errors detected; no single type of error was detected significantly more often than any other. The incidence of errors decreased steadily throughout the survey.

SURVEY RESULTS

A detailed report $(\underline{3})$ is available on the results of the survey. The following section summarizes these results.

Sample

Table 1 presents an overall description of the telephone sample. Interviewers called a total of 22 844 telephone numbers. Of these, 48 percent produced a contact with a household member and 52 percent did not. The complete data set contains 7235 completed guestionnaires.

The number of foreign-language interviews and their relation to the total sample (7235) is given below. However, conduct of an interview was redirected to a foreign-language interviewer only when language presented a barrier to communication. Many Chinese, Spanish, Filipino, Vietnamese, and other minority persons speak English fluently and were interviewed in English. Thus, the numbers presented below do not reflect all interviews with ethnic minorities.

	Interviews		
Language	No.	Percent of Sample	
Chinese	301	4.1	
Spanish	180	2.5	
Tagalog	74	1.0	
Other	79	1.1	
Total	634	8.7	

Table 1. Breakdown of telephone numbers called,

	Telephone Numbers Called		
Category	No.	Percent	
No contact			
Wrong county ^a	367	3.1	
Not a residence	2 6 1 1	21.9	
Recording ^b	6 715	56.5	
No answer (8 calls) ^c	599	5.0	
No answer ^d	1 427	12.0	
Not available ^e	163	1.4	
Total	11 882	99.9	
Total of all numbers		52.0	
Contact made			
Duplicate number ^f	78	0.7	
Wrong number on travel interview ^g	32	0.3	
Language barrier ^h	133	1.2	
Call back ⁱ	175	1.6	
No answer on travel interview ¹	113	1.0	
Unavailable on travel interview ^k	46	0.4	
Refusal			
Preliminary interview	2712	24.7	
Travel interview	438	4.0	
Completed questionnaire	7 235	66.0	
Total	10 962	99.9	
Total of all numbers		48.0	

^a Household reached did not live in county specified in sample. ^b Telephone company recording (number disconnected, changed, etc.). ^{No} answer after afternoon and evening call on three weekdays and Saturday. ^{Last} week of survey, unable to call eight times. ^H Household members ill or out of town for survey duration. ^H Household previously contacted in survey.

^gTravel interview call produced different household than preliminary inter-

view (dialing error). Language other than Spanish, Chinese, Tagalog, or Russian.

Unable to follow through on call-back request (last week of survey). No answer after four successive days following travel day. Household members had moved or were otherwise unavailable for travel interview.

Interviews in the "other" category were conducted by a single interviewer with multiple language capabilities (Spanish, Russian, German, and French).

The distribution of the final sample by county in each case exceeded the number required. The sample distribution was checked for adequate coverage of the 440 MTC travel analysis zones in the nine-county area. The few zones that are not represented in the sample have very small populations. The sample, therefore, appears to provide adequate geographic coverage of the nine-county area.

Incomplete Interviews

Some analyses were done to estimate the direction of bias in the sample due to households that did not provide complete interviews. The evidence suggests that the sample may underrepresent women, older persons, apartment dwellers, and households without a car. The indicated magnitude of these biases is, however, small. We have no information, of course, on households that refused at the outset to participate in the survey. But, as stated in the preceding section, the available census data indicate that this sample does not significantly underrepresent minorities.

SUMMARY

Sampling Method

Directory-based random digit telephone dialing appeared to work well for this survey. An average of 2.1 telephone numbers were dialed to reach a working residential number. Duplicate numbers were avoided by adding one to each number drawn from the directory; fewer than 1 percent of the numbers reached were duplicate numbers. Unlisted numbers could be and were reached by using this method; more than

one-third of the households in the sample have unlisted telephone numbers.

The survey was conducted between March 1 and May 31, 1981. Design and sampling work began in January; the data tape was delivered to MTC on June 30 and the final report in August 1981.

The sampling method also provided adequate geographic coverage of the Bay Area. At least one interview was obtained from almost all of the 440 MTC travel analysis zones; those zones in which no interviews were conducted contained no or very little population. Some problems were encountered with crossovers to different counties; e.g., a number in the sample drawn from an Alameda County telephone directory might be in Contra Costa County. But these crossovers were equal in each direction and therefore did not bias the results.

The sample did not appear to contain significant ethnic biases. Insofar as comparisons with 1980 U.S. Census data were possible, the percentage of minorities in the sample within each county was similar to the reported percentages of minorities in the census.

In comparison with other surveys, this sample appears to represent minorities very well:

Surv	ey	Minority (%)	Nonminority (%)
1965	BATSC	13	87
1970	Census	13-26	74-87
1980	Census	25-36	63-75
1981	survey	31	69

A disadvantage of this sampling method is that households must first be approached by telephone rather than by an official letter. This could cause more refusals. Nevertheless, the refusal rate for this survey was acceptable; initial contact by letter would probably not have produced a significantly lower refusal rate.

Another obvious disadvantage is that households without telephones are excluded from the sample. But fewer than 1 percent of the households in California do not have a telephone. Any bias introduced by this factor is therefore not significant.

It is concluded that the sampling method used for this survey was efficient and effective, provided adequate geographic coverage, and did not introduce significant biases into the sample.

Cost of Telephone Interviewing

The cost of the telephone interviews for this survey is given below:

	Cost per
	Household
Task	(\$)
Interview/edit	10.38
Coding cost	4.43
Supervisor and administrative cost	16.70
Keypunching, programming, and data checks	10.87
Survey design and report writing	7.14
Total	49.52

Comparison of these costs with others is very difficult: Projected costs of surveys not done are word-of-mouth only; costs of older surveys actually done in this area (i.e., the 1965 BATSC survey) are either not available or have become part of the folklore. Estimated costs per survey were \$40-\$80 for a telephone survey, and \$100-\$150 for a homeinterview survey.

Sources of Bias

Every possible effort was made to eliminate sources

of bias in the sampling and interviewing plans. Efforts were directed at reaching apartment dwellers, single-family households, mobile hard-to-reach households, and ethnic minorities, and these efforts were largely successful. However, it is believed that there are some minor sources of bias, as described below.

Households without telephones--1 percent of all California households--were not sampled. Persons who work odd hours, particularly those who work in the evenings, could have been missed, although calls were made during the afternoon as well as the evening hours. Extremely mobile individuals, especially young, single adults, are difficult to reach and are underrepresented in the survey. In fact, the average household size in the sample is higher than in the 1980 Census due to higher probability of persons being home to answer the telephone. The lack of call-backs during the last week of the survey introduces a bias against hard-to-reach households; however, since this procedure represents only 1/10 of the survey, the bias would be a minor one. Households that refused to participate in the survey (28.7 percent) may represent a bias. Data collected on some of these households and individuals show little variation when compared with data on interviewed households; there appears, however, to be a slight underrepresentation of households with low or no car ownership and of elderly persons, particularly elderly females.

RECOMMENDATIONS AND CONCLUSIONS

The three recommendations for future surveys are (a) generate better publicity by augmenting news releases with personal visits to media staff, (b) hire quality interviewers, and (c) modify the travel card, as noted in the section on coding problems, to provide more specific location information. The experience with this survey showed that it is still possible to conduct a household-interview travel survey at reasonable cost and in a short time period. Telephone interviewing is a cost-effective technique for obtaining household travel data. The survey sample provides adequate geographic coverage and is representative of population groups in the Bay Area. It is believed that this success is due to (a) making interviewers aware at the beginning of the need to obtain responses from all population groups and (b) the use of random digit dialing to draw the sample.

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Simultaneous-Equations Analysis of Growth in Bus Route Patronage in San Diego

MICHAEL A. KEMP

An analysis of data describing 40 months' operating experience for the San Diego Transit Corporation bus system is discussed. The analysis used a simultaneous-equations model estimated by using a pooled time-series/crosssectional data base. The model relates the ridership on a specific bus route in a specific month to various influencing factors, particularly the service and fare policies adopted by the system. It also attempts to capture complex interrelations among the influencing factors. The structure of the overall model is summarized. Detailed results, however, are discussed for only one of the five equations in the system, the principal demand equation. Relatively clear bus fare and gasoline price effects were identified, but the separate influence of each of a range of service quality variables (average bus speed, average waiting time, mean stop spacing, and duration of service) was obscured by multicollinearity. Estimates of demand elasticities with respect to a range of different influencing factors are presented, along with associated confidence intervals. Several general conclusions from the analysis are discussed. The work shows that it is possible to use a transit system's time-series operating data in more sophisticated ways than have been customary: The model proved successful in identifying credible structural equations for both demand and supply relations. However, multicollinearity problems are probably intrinsic to the overall approach, and replications of the method are currently strongly constrained by the lack of appropriate computer software. Some potential uses of a model of this type are also discussed.

The San Diego Transit Corporation (SDTC) assumed operation of that city's bus system in July 1967 after purchasing it from a financially ailing private owner. Public takeover was followed by greatly increased funds for capital and operating assistance from local, state, and federal governments, and service was expanded through the introduction of new routes, extension of service periods, and increased frequencies. Between 1971 and 1975 the annual vehicle miles operated increased by 81 percent, route miles grew by 57 percent, and the fleet size and the work force expanded by 54 and 66 percent, respectively.

The service area provided a favorable setting for expansion. Compared with other cities of comparable population and land area, San Diego was growing fast and had a small bus system with relatively low ridership per capita. The large increase in supply, coupled with a major fare reduction in 1972 and a determined effort by the transit management to pro-