

Developing a Household Travel Panel Survey for the Puget Sound Region

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The Puget Sound Transportation Panel (PSTP) is the first application of a general-purpose urban travel panel survey in the United States. Following the Dutch National Mobility Panel, it responds to needs for direct data on the effects of demographic characteristics and transportation conditions on household travel behavior in an urban area. The first-wave travel diaries for the 1,687-household sample in the PSTP were completed in 1989. The sample was stratified by travel mode and residence county. The panel was surveyed for attitudes and values in early 1990, and a second wave of travel diaries was scheduled for late 1990.

Transit agencies and metropolitan planning organizations have long relied on household travel surveys for urban travel data to use in long-range forecasting models, transportation policy analysis, and transit marketing research. These surveys, though in some cases quite large, tend to be infrequent, expensive, and invariably cross-sectional in design. The data are then applied to the analysis of change—for example, policy changes, mode shifts, and the dynamics of future travel. Changes are difficult to predict from data that are fundamentally static snapshots of travel conditions. Yet public policy is often based on inferences from these snapshots, without benefit of direct information on what factors influence personal travel behavior.

Panel (or longitudinal) studies have long been used in economic, demographic, epidemiological, and social policy research, but they are just beginning to emerge as valuable tools in analyzing and predicting travel behavior. The Dutch National Mobility Panel study, initiated in 1984 and continuing into its 10th wave (6-month intervals), is perhaps the longest ongoing transportation-related panel study (1,2). The Dutch panel was designed as a general-purpose longitudinal travel survey and was financed exclusively with public funds. The primary objective was to analyze public transportation policies, but a large volume of research in many aspects of travel behavior has been drawn from the panel data [see van Wissen and Meurs (2)].

Other travel behavior panel studies have been designed for specific research purposes. International examples are in Sydney (3) and Oxford (4). In the United States, panel designs have been applied to evaluations of before-and-after conditions of public transportation policies. Recent examples include studies of high-occupancy vehicle lanes in San Diego, staggered work hours in Honolulu, and telecommuting in Sacramento.

Initiated in 1989, the Puget Sound Transportation Panel (PSTP) is the first general-purpose travel panel survey in an urban area in the United States. It is similar in design and

direction to the Dutch National Mobility Panel but is also descended from the long line of cross-sectional urban travel surveys in the United States and is more focused on transportation and transit policy issues in U.S. cities. Like the Dutch Panel, the PSTP is intended to continue indefinitely into the future, assuming continuation of funding.

CURRENT PRACTICE IN URBAN TRAVEL SURVEYS

During the last 30 years, metropolitan planning organizations (MPOs) have conducted hundreds of urban area household travel surveys for preparing input to travel forecasting models. The objective has usually been to collect information on trip generation rates, zone-to-zone trip tables, and trip length frequencies. Traditionally, surveys have been made of households, using cross-sectional sampling, on the basis of household size, number of cars in the household, and household income.

In the past 4 or 5 years, many MPOs have conducted new regional household surveys to obtain current data for calibrating travel demand models. Examples described include Minneapolis-St. Paul (1982–1983), Denver (1985), Houston (1984), Dallas-Ft. Worth (1984), the Puget Sound region (1985–1988), and national surveys (1969, 1977, and 1983) (5). Other MPOs are planning surveys to coincide with the 1990 census.

In addition, the transit agencies in the Puget Sound region and elsewhere have been active in cross-sectional surveys for marketing and system planning. The Seattle Metro in particular has used surveys of rider and nonrider attitudes to analyze effects on mode choice and travel behavior of local residents.

The 1985–1988 cross-sectional travel surveys by the Puget Sound Council of Governments (PSCOG) originated from concerns by local policy makers about the lack of recent data on trip generation rates (the last previous survey had been in 1971). About \$270,000 was spent on six separate surveys to collect new household data in the four-county PSCOG region. More than 4,500 households were surveyed (of about 1,000,000 households in the region), with travel diaries for all household members aged 5 and over.

Although the techniques of designing and conducting these surveys have changed, the general method and purpose have not. Some of the limitations of this approach when applied to forecasting and policy analysis are as follows:

- The surveys are costly and therefore are conducted infrequently. In the Puget Sound region there was an almost 15-year interval between data collection surveys on household

travel. Increasing trip rates were suspected, and minimal increases had been introduced into the forecasting models. The models were coming up short in forecasting vehicle trips—forecasts for 1990 and 2000 were not even meeting current ground count figures.

- Changes in travel behavior are inferred to be directly related to changes in demographic characteristics. Repeated cross-sectional surveys can measure both travel behavior and demographic characteristics, and both have changed dramatically in the last 20 years. However, it is difficult to know how to predict travel in the future when it is not known how changes in labor force participation or the presence of preschool-age children, for example, have affected travel behavior historically.

- Effects of transportation policies on travel behavior have been built into models using results of cross-sectional studies. Transit fare and automobile operating cost elasticities from cross-sectional data are frequently included as key components of urban travel demand models. But, as with the problem of demographic characteristics, these relationships are used to predict the dynamic impacts of transportation policies, such as transit fare restructuring and gasoline costs, on travel behavior.

PANEL SURVEYS—A DIFFERENT APPROACH

A panel survey is one in which similar measurements are made on the same sample at different times. This may differ from longitudinal data, in which periodic measurements are made on the same variables, but different samples may be drawn. Cross-sectional surveys make no attempt to connect systematically to prior or subsequent surveys.

Duncan, Juster, and Morgan (6) have identified several advantages of a panel design for travel behavior analysis:

1. Direct measurement of individual changes;
2. Ability to analyze causality about changes in place of residence, place of work, and commute mode;
3. Smaller sample requirements for the same statistical reliability; and
4. Lower ongoing costs.

There are also disadvantages (7):

1. Higher initial costs at empanelment,
2. A possible higher nonparticipation rate,
3. Attrition and replacement of the panel, and
4. Locating in-migrants for recruitment (a regional problem).

Perhaps the greatest advantage is that change is measured directly on the respondents themselves, thus permitting inferences to be drawn about the effects of changes in one variable on travel behavior. This cannot be legitimately done with cross-sectional data.

In addition, a panel survey may be a more cost-effective way to collect data during a period of time. This advantage, of course, may depend on the local objectives and resources. Higher initial costs and problems of panel replacement or refreshment could offset the smaller sample and lower on-

going costs. However, analytic techniques have been developed that minimize the panel attrition problem for research and permit statistically valid analysis even when the attrition is serious (8).

Travel behavior and the dynamic character and demographics of urban areas make a strong case for the application of panel surveys for data collection. Change is the norm, not the exception, in our society and its mobility needs:

- Many urban areas are growing,
- Most urban areas are suburbanizing,
- About one in five U.S. households moves in any year,
- This many or more change job locations each year,
- People form and dissolve households and add household members, and
- Household incomes change.

Long-range forecasting of urban travel and the effects of transportation policies on travel behavior depend on the measurement of changes. When aggregates or cross sections are measured, many of the dynamics that affect important aspects of urban travel, such as automobile trip making or transit ridership, are missed.

Application of panel surveys to nontransportation subjects has led to dramatic challenges to prevailing wisdom on behavior and policy that had been derived from cross-sectional studies. Cross-sectional surveys provide snapshots of the population at one or more times. The apparent stability of the population inferred from the similarity of these snapshots is almost always incorrect. The Panel Study on Income Dynamics, for example, has indicated that the poverty population, rather than being mostly the same 10 to 15 percent of the population, turns over rapidly and completely (9). Similar results were found on the nature of welfare recipients (10). It is likely that similar insights can be drawn from transportation panel surveys in the United States once the data have been collected and analyzed.

Although several American researchers, notably Kitamura and Golob, have been active in analyzing the Dutch National Mobility Panel data on various facets of travel behavior, travel behavior and household characteristics in the Netherlands are quite different from current U.S. urban patterns [Dutch data, Kitamura (unpublished), 1989]. For example, in the 1985 (second-wave) data from the Dutch panel, the average number of automobiles per household was 0.90. In the Puget Sound region, the average in 1989 (PSTP telephone "acceptors") was 2.21 vehicles per household. Similarly, the Puget Sound sample showed an average of 1.47 workers per household versus 0.93 in the 1985 Dutch sample; the average Puget Sound household size was 2.77 versus 2.91 in the Dutch sample.

The Dutch data also indicate a much higher proportion of trips by transit, walking, and bicycles than found in U.S. cities. Table 1 compares modes for all trips of households.

The Dutch Mobility Panel data have been extensively analyzed for change or stability in travel behavior with respect to changes in household variables, and the results have even been applied to issues relevant to U.S. transportation policy. It is believed that the differences in transportation systems, travel behavior, and household characteristics between Dutch and U.S. cities are too great to justify such transfer. There is

TABLE 1 HOUSEHOLD TRIPS BY MODE

	Dutch	Puget Sound
	1984-85	1986-88
Auto Drive	25.8 %	68.3 %
Auto Passenger	9.7	19.7
Walk	33.3	5.0
Public Transit (& School Bus)	12.2	6.3
Bicycle/Other	19.0	0.7
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	100.0 %	100.0 %

Source: Dutch data are sample of mobility panel, all trips ages 12 and over (11);
Puget Sound data are from 1986-88 household surveys, all trips ages 5 and over.

need for similar longitudinal data from American urban areas to support such behavioral and policy analysis.

PSTP

The PSTP, begun in 1989, is being conducted by PSCOG in partnership with the transit agencies in the region. The funding is from a special transit data grant administered through the Washington State Department of Transportation, covering two waves, 1 year apart, with intervening supplementary surveying.

The panel is intended to serve three basic objectives:

- To be a metropolitan “current population survey” to track changes in employment, work characteristics, household composition, and vehicle availability;
- To monitor changes in travel behavior and responses to changes in the transportation environment; and
- To examine changes in attitudes and values as they affect mode choice and travel behavior.

Sample Stratification

The survey plan is for a regionwide sample of households with stratification based on usual mode of choice (transit, carpool, or drive alone) and geography. As such, the panel consists of three discrete household populations:

- Households without regular (four one-way trips per week) transit users or carpoolers,
- Households with regular transit users, and
- Households with regular (work trip) carpoolers.

Each of these samples is further stratified by county of residence. The transit user sample is stratified by transit operator (five in four counties). The objective of these stratifications

was to ensure that in all but a couple of cells there would be a sufficient sample for valid analysis.

Kitamura (12) has demonstrated that stages in the household life cycle are important for the analysis of travel behavior and future changes in behavior. So, each household in the PSTP is also classified by life-cycle stage for analytic purposes, though the sample was not stratified as such when drawn. The following eight stages are used here:

1. One adult less than 35 years old without children;
2. One adult 35 to 64 years old without children;
3. Two or more adults less than 35 years old without children;
4. Any number of adults, any age, with pre-school-age children (under 6 years old);
5. Any number of adults, any age, with school-age children (6 to 17 years old);
6. Two or more adults 35 to 64 years old without children;
7. Two or more adults 65 years old or older without children; and
8. One adult 65 years old or older without children.

Survey Method

The empanelment plan called for the use of three different means of contacting potential panel members.

- Telephone random digit dialing (the primary source, effective for nontransit-noncarpool and carpool households,
- Recontact of respondents on Seattle Metro transit surveys who had indicated willingness to participate in further research, and
- Distribution of letters on randomly selected bus runs requesting volunteers.

Transit ridership in the Puget Sound region is proportionally too small to obtain a valid transit sample by using telephone random dialing without an extraordinary number of contacts—as many as 20 calls for every regular transit user.

The primary means of data collection on household trip behavior is a 2-day trip diary completed by each household member aged 15 and over. The diaries were mailed out after initial telephone contact and screening, filled out, and returned.

Trip diaries are the standard instrument for reporting of objective trip data. A 1-day diary is commonly used in cross-sectional studies but can be insufficient for analyzing changes in travel behavior from one time to another, in light of the known variability in travel across days of the week. The Dutch panel uses a 7-day diary, but Golob and Meurs (13) report on diary fatigue as trip recording falls off markedly and uniformly over the week. Kitamura (14) recommended a diary period of 2 to 3 days—sufficient for panel analysis but not onerous enough for significant fatigue—administered at intervals no less than 12 months apart.

Diary Incentives

The subject of incentives to respondents in diary surveys has been of interest to researchers for a long time. Prevailing

opinion among survey researchers has favored use of incentives to complete travel diaries, though the approach and amounts appear to vary widely. After some lottery approaches were discarded for legal and political reasons, three alternatives to monetary incentives were considered for the PSTP: (a) no incentive at all, (b) \$1 for each household member (attached to the diaries when mailed out), and (c) \$10 for each household returning a completed diary. The staff and the survey consultant decided to test the alternatives in the first wave of the panel. Households agreeing to participate in the telephone contact were randomly assigned one of the three groups for the dairy mailout.

After tabulating diary returns from approximately 1,500 households assigned equally among the incentive groups, the survey consultant reported that the \$10 per household postcompletion alternative was performing about 10 percent above the no incentive alternative and about 5 percent above the \$1 per person precompletion alternative. At that point, all further mailouts were shifted to the \$10 per household postcompletion incentive.

Later results indicated that the \$1 per person precompletion alternative performed somewhat better than the \$10 per household postcompletion alternative (see the following table, which contains data as of December 8, 1989).

Alternative	Mailouts Returned (%)
No incentive	49.3
\$1 per person precompletion	63.9
\$10 per household postcompletion	60.3

The conclusion from this experiment, therefore, is that monetary incentives positively affect diary return rates, but it is not clear which alternative provides better results.

FIRST-WAVE EXPERIENCE

The first-wave data collection took place from September to early December of 1989 (excluding the Thanksgiving holiday week). A total of 5,152 households were contacted by telephone (including transit recontacts and volunteers). Of these, 2,896 agreed to receive diaries, and 1,687 returned completed diaries (Figure 1).

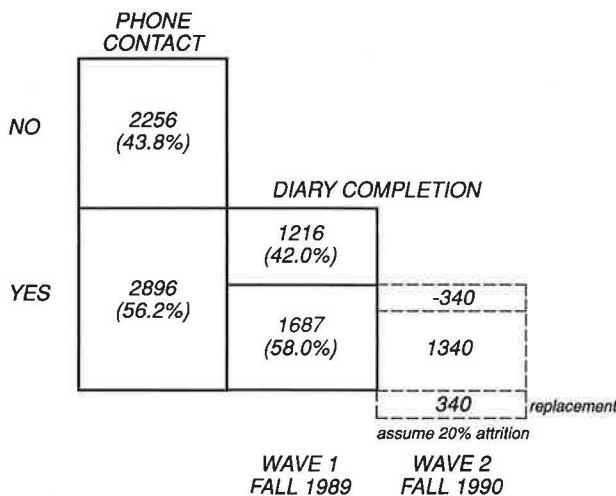


FIGURE 1 Acceptance and completion of Wave 1, 1989.

One unexpected problem in the first-wave data collection was a strike by 45,000 Boeing mechanics that started in early October. A number of households with striking workers were among the survey participants. The decision was made to hold the diaries for these households, because the strike obviously altered the travel patterns of household members. The strike lasted for 50 days and ended just soon enough to obtain travel diaries from the households right after the Thanksgiving week, before closing the survey.

All households who were contacted on the telephone were asked a brief series of questions before being asked to participate in the panel. There was a lower acceptance rate for this request than for travel diaries in previous cross-sectional surveys conducted by PSCOG, as indicated in the following table. But, interestingly, of those agreeing to participate in the panel survey, a slightly higher percentage completed and returned the diaries than in the earlier surveys.

	Survey Response Rates (%)	
	1985-1988 Surveys	1989 Panel
Acceptance at telephone contact	62	56
Diary completion after acceptance	55	58

There is usually some bias in the characteristics of households who choose to participate in a panel survey compared with those who refuse. Table 2 presents several comparisons between households who accepted panel participation and those who did not. Table 3 compares households who completed the diaries with those who accepted the diaries but did not return them.

There were limited differences between households who refused and those who accepted. Those who accepted

- Were slightly younger,
- Had more young children,
- Resided a shorter time in their county, and
- Rode buses more regularly.

There were more pronounced differences between the group of acceptors who completed the diaries and those who did

TABLE 2 TELEPHONE CONTACT ACCEPTORS VERSUS REFUSERS

Average Values for	Agree to Join	Refuse to Join	Statis. Signif.*
Household Size	2.781	2.786	No
No. Employed/Hshld.	1.472	1.453	No
No. Vehicles/Hshld.	2.203	2.252	No
Age of Phone Respondent	42.9	45.7	Yes
No. of Persons <age 6/Hshld.	0.260	0.225	Yes
No. Bus Riders/Hshld.	0.418	0.250	Yes
No. Carpoolers/Hshld.	0.246	0.202	Yes
Years in County	14.79	15.60	Yes

* statistically significant at +/- 5%.

TABLE 3 ACCEPTED AND COMPLETED VERSUS ACCEPTED AND NOT RETURNED DIARIES

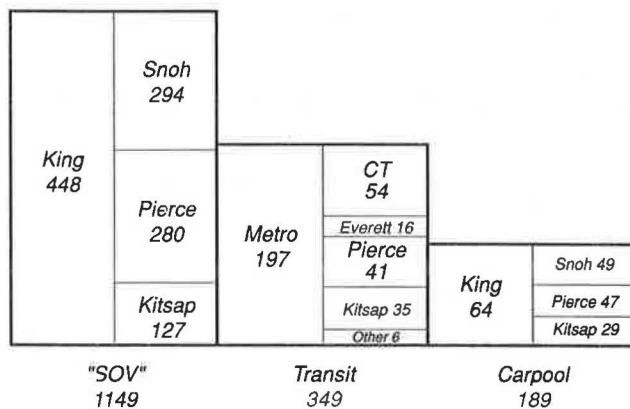
Average Values for	Completed	Did Not	Statis.
	Diaries	Complete	Signif.*
Household Size	2.595	3.041	Yes
No. Employed/Hshld.	1.362	1.626	Yes
No. Vehicles/Hshld.	2.120	2.319	Yes
Age of Phone Respondent	44.8	40.3	Yes
No. of Children <Age 6/Hshld.	0.235	0.296	Yes
No. of Bus Riders/Hshld.	0.266	0.484	Yes
No. Carpoolers/Hshld.	0.223	0.270	No
Years in County	15.18	14.24	Yes

* statistically significant at +/- 5%.

not. Those who completed the diaries

- Were slightly older,
- Had fewer young children,
- Resided a longer in their county, and
- Rode buses less regularly.

The composition of the panel as now constituted is shown in Figure 2. There are 1,687 households in the panel after the first wave, consisting of 1,149 nontransit-noncarpool households, 349 regular transit-using households, and 189 regular carpooling households. By county of residence, 709 are in King County, 413 in Snohomish County, 374 in Pierce County, and 191 in Kitsap County.



Transit - at least one person in household makes at least 4 one-way trips by transit each week.

Carpool - at least one person in household makes at least 4 one-way trips in a carpool to work each week.

FIGURE 2 Panel composition, Wave 1, 1989.

Preliminary analysis of total household trips for the entire sample indicates some trip reporting fatigue, even with the 2-day diaries. On the average, the results indicated 9.19 trips per household on Day 1 of the diaries and 8.81 trips per household on Day 2. Further analysis will compare Day 1 and Day 2 reporting with day of the week held constant. These average trip rates from the panel are lower than those from the 1985-1988 regional cross-sectional sample. However, the PSTP has a disproportionate number of transit-using households, which may contribute to the lower overall trip rate in this preliminary analysis.

NEXT STAGES AND PANEL ISSUES

The second-wave survey for the PSTP was scheduled for the fall of 1990. Duncan, Juster, and Morgan (6) have emphasized the critical importance of continuous "care and feeding" of panel participants, especially to minimize attrition between waves. Consequently, several follow-up efforts are under way to maintain contact (and update records) between the first and second waves. They include (a) a holiday card in late 1989 thanking panel members for their participation in the first wave; (b) a survey on panel attitudes and values administered in early 1990; and (c) a postcard seeking address changes in mid-1990.

Attitudes and Values Survey

Developing a longitudinal relationship between attitudes and values of transit and nontransit users and their travel behavior has been a keen interest of marketing staffs of the transit agencies in the region. The PSTP appeared to provide an important opportunity to analyze this relationship. It was decided to combine a survey of attitudes and values with a follow-up contact with the panel participants several months after the first-wave travel diaries.

Attitudes and values, as used here, is meant to cover the psychological aspects of mode choice, including attitudes, feelings, perceptions, and preferences. Examples of analyses of these phenomena are contained elsewhere (15-17). Market researchers for transit operators and carpool coordinating agencies are particularly interested in identifying factors outside the rational decision-making process that may influence or even control individual mode choice. The hypothesis is that travel behavior and changes in it are related to distinct and identifiable psychological factors. The problem is to measure the two together.

Local transit agencies have developed a good sense of their rider populations at particular times through on-board surveys, but they are becoming more aware that there are continuing fluctuations between rider and nonrider status. The same can be said for those who may be carpooling at any one time. The PSTP provides an opportunity for the transit agencies to obtain a baseline of data on attitudes and perceptions, along with measured travel behavior and demographics of households. Subsequent waves of travel diaries will permit analysis of changes in travel behavior (e.g., transit rider to

drive alone and drive alone to carpool) and changes in demographics (e.g., residence and work location) with respect to the attitudes of changers and nonchangers.

The attitude survey instrument was designed by a group of transit agency staff and researchers from the University of Washington. The survey included questions on

- The importance of 17 attributes,
- The performance for three modes of 17 attributes,
- Attitudes toward three modes, and
- Constraints (e.g., need of a car for job, distance from home to nearest bus stop, and vehicle availability).

The survey was administered on a mail out-mail back basis in February and March 1990 to 2,928 persons in the panel households on the basis of their ages and labor force participation. Results were to be available later in 1990.

Survey Unit to Follow

The issue is whether to follow the household unit over time or to follow individual members of households as a population. For the PSTP, the decision was made to use the household as the survey unit. The reasons are partly because of the travel data and forecasting work previously carried out at PSCOG and partly because the travel behavior of individuals is often influenced by characteristics of the household, such as vehicle availability and the presence of children.

Because there will be events (such as births, deaths, marriages, and separations) that change the household structure of panel members, the survey must make accommodations to the changes. The PSTP will follow and include persons from panel households as they leave and form new households if they remain in the region. Likewise, persons who join a panel household (e.g., through marriage) will be asked to join the panel. These changes may introduce some panel composition bias over time.

Panel Attrition and Refreshment

Attrition of panel participants between survey waves is a normal and expected problem of panel designs. The Dutch National Mobility Panel lost 40 percent of its households during the first year; the Panel Survey on Income Dynamics lost 15 percent. So, whatever the level, there is inevitable attrition in panel surveys. The attrition tends to be biased, occurring more in some demographic groups than others. The choices in panel survey administration are whether to replace lost households, and, if so, by what means. Duncan, Juster, and Morgan (6), from their extensive experience with the Panel Survey on Income Dynamics, still maintain that panel designs with refreshment are more cost-effective than repeated cross-sectional surveys.

Households drop out of panel surveys from one wave to the next for a variety of reasons. The most straightforward reasons for a regional panel will be death or moving out of the region; the latter has not been a significant problem in the national panels on Dutch mobility or the U.S. Panel Survey on Income Dynamics. In the Puget Sound region, as much

as 5 percent of the population leaves the region each year, and recently almost twice that number has been entering. But there is attrition among those remaining in the region due to moving and becoming "lost" and to choosing not to participate further, for any number of reasons. The Dutch panel has found higher rates of attrition from lower-income households, singles, and retirees (2).

The biased attrition creates a potential problem for analysis of longitudinal data from panel surveys as well as for refreshment of the panel. Kitamura and Bovy (8) have demonstrated a technique for analyzing panel data, correcting for bias through a probabilistic model of household attrition applied as a weighting factor to remaining households. Refreshment of the panel should attempt to maintain overall representativeness of the population by adding new households that resemble the lost ones as closely as possible.

Replacement of households is a particular problem with a regional panel like the PSTP. Despite efforts to follow the panel members as closely as possible to minimize attrition, a significant level of attrition is expected. It will be necessary to find additional households within the region, including in-migrants, to maintain the profile of the panel. The problem of locating and contacting in-migrants is especially difficult. In-migrants can be identified through several data bases:

- Real estate transaction records,
- Driver's license changes,
- Motor vehicle registrations, and
- New residential telephone service.

But each of these has flaws—some records will not reflect intrastate moves, driver's license has a lag problem, real estate misses renters. A different approach is to contact new residents of dwelling units of panel out-movers, but this does not guarantee finding regional in-migrants.

The likely approach for the PSTP is to sample randomly for additional households and to find explicit in-migrants through one or more of these data bases. The approach will be finalized in mid-1990 and applied as contacts are made during the second wave in the fall of 1990.

CONCLUSION

Panel surveys have been in widespread use in many fields for years but are only recently entering research in transportation. There is solid evidence that panel data can significantly add to the understanding of urban travel and assist in its forecasting and the application of public policy to it. The experience of the Dutch National Mobility Panel demonstrates how a general-purpose panel can be accomplished and internalized as a regular governmental data collection and analysis activity.

The PSTP is the first such effort in the United States. It has now been launched and within 1 year will be producing data for analysis. Issues remain to be resolved, but that is normal for a new enterprise. This panel may provide insights into travel behavior in the Puget Sound area that can be reasonably applied to other U.S. regions.

Most important, the experience may enable other metropolitan regions (such as the San Francisco Bay Area, which

is planning a 1990 start) to move toward panel surveys and their richer potential for forecasting and policy analysis.

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