GPS-Assisted Prompted Recall Household Travel Survey to Support Development of an Advanced Travel Model

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Introduction

Promising advances in travel modeling are linked to the presence or absence of requisite data to support innovations in modeling. Standard data inputs for these models are obtained from household travel surveys (HTS) in which representative households are recruited to complete single or multiple day travel diaries and to report this travel information during a computer-assisted telephone interview (CATI). Respondent burden associated with this collection method is thought to be substantial, resulting in unit and item non-response as well as inconsistent data.

Since the full implementation of the Global Positioning System (GPS) in the mid 1990's, transportation planners and researchers have held great hope that the passive collection of travel information via GPS could be used to reduce respondent burden while improving the quality, quantity, and comprehensiveness of model input data. From 1996 through 2006, the primary use of GPS technology in HTS was to audit the CATI collection trip information. The early adoption of using GPS data to audit diary data rather than to replace travel diaries was due to high equipment costs of first generation GPS devices and to the lack of experience in using GPS data for travel models.

Now inexpensive, wearable GPS logging devices are available, and it is possible to build upon past small sample work to conduct a full scale HTS based entirely on person-based GPS capture. Past reasons for relying on vehicle-based GPS – size, weight, power-demand, and overall form factor of the early GPS equipment – no longer matter. Full-scale person-based GPS can be used to support the demanding needs of advanced Activity-Based travel Models (ABM).

The Context of the Paper

Our paper describes the design and implementation of a GPS-assisted HTS that was specifically planned to support development of an advance Activity-Based travel Model (ABM). It utilizes an innovative surveying technology known as "prompted recall" with 100% of all households being equipped with a GPS device. The Jerusalem project offers a unique opportunity for travel modelers and survey experts to consolidate their efforts and focus on the most important data issues from the modeling perspective and to utilize the most advanced data collection technology available in practice on a large regional scale.

In general, data needs for development of an advanced ABM can be summarized in the following four major aspects that result in the corresponding requirements for the Household Travel Survey:

- **Completeness of individual daily patterns**. ABMs operate with disaggregate individual daily patterns and schedules. From this point of view, it is essential to collect a full-day list of person trips and activities with no gaps or inconsistencies. If one of the trips or activities is missing, miscoded, or underreported, this essentially makes the entire person-day unusable for some of the ABM components. Underreporting in aggregate 4-step models can be somewhat fixed by applying trip rate correction factors derived, for example, from a 10-15% subsample of GPS-assisted households.

This approach is less useful for ABMs since it is impossible to restore the individual disaggregate details (that include not only the number of trips by purpose but also their sequence and timing) based on a small sub-sample. The advanced surveying technology that fully addresses this issue and minimizes the underreporting biases is 100% GPS-assisted prompted recall method.

- **Intra-person time-space consistency**. Another issue that has been plaguing HTS and subsequent travel model development for many years is geo-coding of locations (trip origins and destinations) and ensuring proper trip arrival and departure times. For any travel model (either 4-step or ABM) a trip record with unknown destination location is unusable for most of sub-models. Rounding and other mistakes in trip departure and arrival times are less critical for 4-step models since they operate with broad 3-4 hour time periods. However, advanced ABMs are extremely sensitive to both spatial and temporal inconsistencies. Moreover, since they operate with tours rather than trips, having a data item missing on one of the trips frequently results in discarding the entire tour. Essentially, an ABM requires a fully consistent daily schedule for each person tracked in time and space with a fine level of spatial and temporal resolution. The only technology that ensures such a consistent daily chain of trips and activities recorded for a person is a GPS stream. This resolves both spatial and temporal aspects with the necessary level of details that can be derived from the stream.
- **Inter-person intra-household consistency**. Advanced ABMs explicitly model intra-household interactions associated with joint activities and travel. The CAPI/CATI technology facilitated by GPS-based prompted recall allows for automatic edit checks for identification of joint activities and trips and carrying information obtained from one household member to other household members' diaries during the survey. It is essential, for example, to collect and quickly process trips made by children if they are escorted by adult household members – a frequent case in Jerusalem due to a large household size.
- **Rich set of behavioral responses including new projects, transportation technologies, and policies**. Another well-known problem with conventional HTS is that in many cases they do not provide enough trade-offs between various mode and time-of-day choice options as well as cannot portray travelers' responses to new modes and policies that do not exist yet (or applied only on a minor scale). New transit modes and highway pricing policies are amongst the most frequent options not covered by HTS. Both options are of great importance for Jerusalem since the JTMT is currently considering new LRT and intercity rail lines as well as envisioning various pricing policies. The usual method to address non-existing travel options is a Stated Preference (SP) survey. Our Jerusalem survey design contains many interesting variables that are not traditional in HTS (like parking at the home end, usual work and school schedules). In addition, the approach adopted for the Jerusalem project is to integrate SP surveys within the Household Travel Survey as focused extensions. After the basic interview has been completed, one of the trips made by one of the household members is chosen as the basis for one of the planned SP extensions. The SP extension type will correspond to a realist project/policy depending on the trip origin, destination, purpose, and time-of-day. This ensures full realism in terms of the SP scenarios as well as in terms of the baseline level-of-service variables extracted from the actual GPS stream. This also provides all household, person, and situational variables (like number of trips implemented by the person before and after the chosen one) that are not available in stand-alone SP surveys.

The pilot test for the Jerusalem HTS will take place early in 2010, with a large sample that can be analyzed for purposes of the paper to be presented at the Innovations in Travel Modeling 2010. The survey will collect 100% GPS data for all members (age 16 and over) of 240 households for a 24-hour period. The survey design assumes that GPS data collection is the default. Persons who do not accept

the GPS will be provided with a traditional travel diary. All interviewing will be done via computer-assisted personal interviewing (CAPI) on laptop computers. In the visit to the household after the travel day, the GPS data will be downloaded to the laptop and used to conduct a prompted recall interview based on the GPS traces.

The Research Questions

As described above, the GPS-assisted HTS will provide requisite data capture improvements necessary for innovative travel models. Most of the equipment and data processing issues associated with GPS-assisted HTS have been successfully addressed in previous studies. But it should be mentioned that GPS-prompted recall is not perfect. We know our participants will not be perfect in the sense of carrying the devices all the time and carrying or wearing them properly. There will be cases where we are missing some parts of the trips, entire trips, and even some entire days. These "non-perfect" experiences will be documented so that prescriptive remedies can be provided for future applications.

But the biggest "unknown" in the application of full-scale GPS-assisted household travel survey relates to respondent acceptance of this technology. While previous studies have documented the characteristics of respondents who accept or do not accept GPS equipment, there is no unified theory of respondent acceptance to inform or predict the diffusion of this technology as the form factor continues to improve and the cost continues to decrease. Toward this end, the authors use the event of a pilot test for a GPS-assisted household travel survey to conduct an empirical exploration for a theoretical framework to predict respondent acceptance of this technology. We will explore the factors affecting respondents' attitudes toward technology in general, and GPS technology specifically, to test the relationship of these with behavioral intention to accept the GPS equipment.

In the course of this study, three theoretical frameworks (i.e., the theory of reasoned action, the technology acceptance model, and the theory of planned behavior) will be reviewed to construct an integrated framework, which explains attitude-behavior relationship in GPS equipment acceptance. In particular, the authors would like to introduce the construct of a "trusting attitude" as an independent variable that further strengthens the theoretical framework. Several information systems (IS) studies have investigated consumer trust with an e-vendor and/or the e-vendor's web site. Existing research has acknowledged the importance of trust in aspects of information systems, but there has been little focus on trust in a specific information system or technology. A secondary purpose of this research, therefore, is to extend an existing model of trust in IS and apply it to the context of GPS systems.

Based on the results of the pilot test, prior literatures, and a proposed framework, our paper intends to answer the following research questions: (1) How do respondents perceive the use of GPS for travel data collection relative to traditional diaries and what are the documented "imperfect" use of GPS by respondents? (2) What is the most important factor affecting positive or negative attitudes towards acceptance of GPS equipment? (3) What is the relationship between attitudes towards the use of GPS technology and behavioral intention in accepting the GPS in lieu of a traditional diary? (4) Can theoretical frameworks that explain technology acceptance be extended to inform and predict GPS acceptance for household travel surveys? (5) Can GPS-assisted prompted-recall HTS reliability be used to support the development of advanced travel models? The result of this research is expected to help researchers and practitioners understand the critical components of the use of GPS for current and future household travel surveys.