Measuring Travel Time Burden by Activity Type using Tours in the American Time Use Survey

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Introduction and Research Objectives

It is important when assessing travel burden or costs to be able to consider the amount of travel undertaken by activity type or purpose for different individuals. This is straightforward in the case of single purpose trips. For example, in the case of home-to-store-to-home all of the travel time in both directions is for the purpose of shopping. However, the pattern of pursuing activities in tour or trip chains complicates not only data collection for transportation planners and modelers, but also allocation of travel time by activity. For example, In the case of a tour from home to dentist to store to home, it is unclear how much travel time should be associated with personal health care and how much with shopping. The travel time burden associated with participation in both necessary and discretionary activities is important in the study of activity and time use as it relates to quality of life.

The objective of this paper is two-fold. First, we propose an algorithm for extracting tours from activity data and estimating the travel time associated with stops and activities within home-based and work-based tours. Second, our work demonstrates the usefulness of the American Time Use Survey (ATUS) as a source of travel and activity data that has been relatively underutilized by transportation researchers and planners. Designing and conducting surveys, especially activity-based travel surveys, is both cost- and time-consuming. Therefore, it is critical to assess the utility of this available ATUS resource to provide rich data regarding people's activity patterns or travel episodes.

American Time Use Survey (ATUS) Data

The American Time Use Survey (ATUS) is conducted by the Bureau of Labor and Statistics (BLS) to collect information on how US residents spend their time on a selected day. A 24-hour time diary is collected from a subpopulation of those who have recently completed the Current Population Survey. The sample is conducted on a rolling basis, with new participants added each month. The version utilized in this study was collected in 2007. In addition to the respondent's household demographic information, ATUS collects activity details including who was present during each activity and whether any childcare took place as a secondary activity. When coded, ATUS data includes a time series for over 400 activity types (75+ of which are travel), activity location (11 of which are travel modes) and the duration of these activities in minutes. Although the full dataset includes activity observations for over 116,000 individual, this algorithm development utilities approximately 6,000 individuals used in another study of women with children (Gekas et al., 2009).

Algorithm and Application

Although ATUS is a powerful data set, its travel time allocations require re-tabulation before it can be utilized to accurately estimate travel times by activity purpose. The basic ATUS coding rules appear to systematically underestimate travel time by purpose, particularly for trips that end at home. In an attempt to remedy this, our approach consisted of 4 main steps: 1) data corrections; 2) identification of travel episodes; 3) identification of four classes of tours; and 4) re-calculation of travel time by purpose or activity type based on the algorithm described below. In this case, we classified tours in terms of those that began and ended at home (H-H), began at home and ended at work (H-W), began at work and ended at home (W-H) or began and ended at work (W-W). In other words tours were anchored at

either end by either home or work. In the brief outline below, the analysis steps are described with two main goals: first, to attribute each activity to a specific tour type; and second, to assign travel time to each particular activity. This includes division of all travel time within a tour between all purposes on the tour not just purpose that followed a given leg. This assignment of travel time to activities is particularly critical if researchers are interested in the travel burden associated with participation in certain activities for certain individuals.

Table 1 shows a typical travel log recorded for one surveyed person identifiable by the unique "time use case ID (CASEID)". The second column is an activity index. In this case, the individual reported a series of 23 activities in the day. The "Where" field uses integers to indicate where each activity took place and if the activity was travel-involved the "where" column would identify the transportation mode used for that travel episode. In the example shown in Table 1, "12" corresponds to "a car, truck or motorcycle". Activity duration measured in minutes is then recorded for each activity. The activity codes are numerous and can be cross-referenced with a detailed codebook. Though the information recorded in the travel log is rich and highly detailed, there are two critical pieces missing from the data for this research purposes. First, for any single activity reported in the survey, the details of the daily schedule or the context of the specific activity is not immediately evident. The context is contained in the sequence of data rows. In other words, information of relevance to the whole daily schedule is missing from the observation of a specific activity. Second, the travel time recorded for a specific activity is usually just the duration of the travel episode or trip leg immediately prior to the activity. Therefore, in a trip-chain or tour, the accuracy of the travel time is dependent on the sequence and spatial separation of stops. In the case of commuting, the travel may often be underestimated if there were stops on the tour.

No survey ever provides data ready-to-use for all purposes and so this re-tabulation to study travel time is not unreasonable, but it is complex. There are two main steps for re-tabulating the travel time in the survey data. The first step is to complete the "unfinished tours" which refer to tours with either the beginning or end anchor (as "home" or "work") missing and causing activities unidentifiable by tour type. Since these unfinished ends normally occur at the beginning or end of a surveyed day, the authors assumed that the missing anchor was "home" for either the missing beginning or end. The second step is to remove miscellaneous activities that are unattached to any travel episode and not included in any identifiable tour. Most of these activity episodes were coded as 1 or -1 which corresponds to personal maintenance activities conducted at home and not relevant to travel time analysis.

Table 1 Sample of ATUS raw data

CASEID	Activity Index	Where	Duration	Activity Code
20070101071350	1	-1	210	10101
20070101071350	2	-1	30	10201
20070101071350	3	1	10	20601
20070101071350	4	1	15	30101
20070101071350	5	1	15	500101
20070101071350	6	12	5	180501
20070101071350	7	2	225	50101

20070101071350	8	12	5	181101
20070101071350	9	1	60	110101
20070101071350	10	12	5	180501
20070101071350	11	2	270	50101
20070101071350	12	12	15	180704
20070101071350	13	7	50	70104
20070101071350	14	12	20	180704
20070101071350	15	7	5	70104
20070101071350	16	12	10	180704
20070101071350	17	1	10	110101
20070101071350	18	1	60	120303
20070101071350	19	1	75	130105
20070101071350	20	1	120	120307
20070101071350	21	1	90	120101
20070101071350	22	1	105	120303
20070101071350	23	-1	30	10101

The following assumptions were adopted for data reformatting.

1. "Where" code "1" represents the "respondent's home" and "2" stands for the "respondent's workplace" was used for forming the tours. If a "1" locations appears before a travel episode, the tour is considered to originate from home; if a "2" appears after a travel episode then the tour is considered to end at work; and vice versa.
2. Tours that started from "home" and ended at "home" or started from "workplace" and ended at "workplace" were required to have at least one non-travel activity conducted in between. This assumption was aimed to reduce the impact of miscoding that resulted in "traveling for no purpose".
3. For cases where the traveler did not code either "1" or "2" before the first travel episode of the day the tour is then assumed to originate from home; and where the traveler did not code either "1" or "2" after the last travel episode the tour is assumed to end at home.

Table 2 shows the steps used in the algorithm which is described below to identify the four type of tours.

1. All travel episodes were identified and flagged in the dataset (shown as shaded in the "where" column in Table 2).

2. For each travel episode, the algorithm looks backward in time and finds the adjacent "1" or "2" and forward in time to find the adjacent "1" or "2" after it. Once the home and workplace anchors are identified, the algorithm then assigns all activities between anchors to the appropriate tour type.

3. Each tour identified was also assigned with a unique ID which allows users to efficiently identify different tours of the same type conducted by the same respondent.

4. For all the tours identified, two separate datasets were created, one containing only non-travel activities already tagged with tour types and the other one containing only travel episodes also tagged with tour types. The two datasets can be remerged together using the tour ID.

5. The last step was to derive the number of activities per tour from the activity dataset. The total travel time for the tour was summed. Travel time was assigned proportionately to all activities in the tour. If the tour has more than one trip purpose or stop the average travel time was used. In other words if a tour of 30 minutes started and ended at home and had three stops. A travel time of 10 minutes was allocated for each purpose.

Table 2 Steps of algorithm used to identify tour-types and reassign travel time

CASEID	Activity Index	Where			Duration	Activity Code
20070101071350	1	-1			210	10101
20070101071350	2	-1			30	10201
20070101071350	3	1	Last home/work "TEWHERE" identified before travel		10	20601
20070101071350	4	1			15	30101
20070101071350	5	1 →		Home-work	15	500101
20070101071350	6	12	First home/work "TEWHERE" identified after travel		5	180501
20070101071350	7	2 →			225	50101
20070101071350	8	12		Work-home	5	181101
20070101071350	9	1			60	110101
20070101071350	10	12		Home-work	5	180501
20070101071350	11	2			270	50101
20070101071350	12	12			15	180704
20070101071350	13	7	Work-home with activities		50	70104
20070101071350	14	12			20	180704
20070101071350	15	7			5	70104
20070101071350	16	12			10	180704
20070101071350	17	1			10	110101
20070101071350	18	1			60	120303
20070101071350	19	1			75	130105
20070101071350	20	1			120	120307
20070101071350	21	1			90	120101
20070101071350	22	1			105	120303

Results

Once the activities were tagged by tour type and travel times were re-estimated by purpose, it was possible to summarize results considering tour types and also travel times. The immediate results of this reformatted data fall into three classes. First, it is possible to compare the number of single purpose trips versus multi-stop trips or tours. For home-work tours/trips, the women with children in this dataset make 41% of their tours with no stop, 39% with only one stop and 20% with more than one stop from home to work. For work-home tours/trips, the same women make 46% of their tours with no stop, 28% with only one stop and 26% with more than one stop from work to home. The large percentage of tours speaks to the importance of developing robust methods to consider travel time and other factors as they relate to tours not trips.

Second, the relative number of home-based versus work-based tours can be considered. For the women with children, in total, 1,783 tours were conducted between home and workplace, 3,431 tours started from home and ended at home, but only 202 tours started from work and ended at work. Third,

the amount of travel time or travel time burden by trip purpose can be assessed. Table 3 shows the average, 25th percentile and 75th percentile travel time in the 24-hour. In this table the numerous activity categories of the ATUS were aggregated into groups. Of all the categories, travel time for personal leisure activities is largest. The second largest amount of travel time spent was for household errands which equated to an average of over an hour a day. The two right columns in Table 3 illustrate the large difference between individuals in the sample.

Table 3 Travel Time per Day by Activity Category

Activity Category	Average travel time (min)	25^{th} percentile travel time (min)	75^{th} percentile travel time (min)
Household Errands	66	28	85
Work	21	8	25
Education	21	8	30
Consumer Activity	27	11	34
Personal Leisure Activity	79	17	49
Religious Activity	17	9	19
Personal Care Activity	39	29	95
Civic Obligation	17	7	20

Summary

This analysis demonstrates that ATUS is a rich data source valuable to transportation researchers. While the lack of geospatial data, such as origin and destination locations, is limiting, the other detail is useful and opens up great potential for future studies related to travel behaviors and decision making, utilizing ATUS records. This analysis shows it is not straightforward to estimate travel time by purpose when tours dominate activity schedules. The algorithm adopted to reformat the original ATUS data demonstrates its capability in recognizing tour-based travels as well as assigning travel time by purpose. Although this enables associating an exact amount of travel time to a specific activity, more advanced steps have to be taken before the more detailed and cohesive activity-based schedules of (ATUS) respondents can be revealed and further explored.

References

Cassandra Gekus, Lisa Aultman-Hall, Chen Zhang. "The Allocation of Travel Time during Trip Tours: An Analysis of Low-Income Women with Children", the 89^{th} annual international meeting of Transportation Research Board, Jan 10^{th} – 14^{th}, 2010