

Trips, Chains, and Tours—Using an Operational Definition

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Abstract

This paper presents the results of an effort funded by the FHWA Office of Policy to conduct analyses for creating tour-based files for the 1995 Nationwide Personal Transportation Survey (NPTS) and the 2001 National Household Travel Survey (NHTS). This research examines the effect of different rules of inclusion for person-trips within chains and advances an operational definition of a trip chain as containing stops for any purpose with no more than 30 minutes dwell time. We describe the process of establishing tours based on this definition, including the number and percent of trips included by tour type, the number and percent of tours established, and a closer look at the tours for journey-to-work. We look at the differences in estimates of commute trips and miles using person-trips and tour-level analysis using the tour-level files for 1995 and 2001. These files and a more detailed description are available for researchers from the FHWA.

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Overview

Trip chaining is a relatively new way to look at the series of trips made by people every day, and there is no formal agreement on the definition of a chained trip. At its most basic level, a chained trip includes a stop on the way to another destination. Although transportation planners have been aware of the behavior for nearly a quarter of a century, little empirical research on the effect of different definitions of a chained trip has been published. Different terms and expectations exist as to what types of trips should be considered part of a chain, what anchors should define a tour (Home, Home and Work, Home and Work and Other), and whether only trips for certain purposes (e.g. dropping a passenger) or only trips with certain dwell-times (e.g. 15 minutes or less) should be considered an intervening stop in a trip to a more substantive destination.

To aid researchers and to set the stage for a common definition of a trip chain, the Federal Highway Administration recently conducted research into the effects of different definitions of what constitutes a chained trip. This research uses data from the 2001 National Household Travel Survey (NHTS) and the 1995 Nationwide Personal Transportation Survey (NPTS).

As a result of the research conducted in this process, FHWA has developed an operational definition of a “trip chain” as a sequence of trips bounded by stops of 30 minutes or less. A stop of 31 minutes or more defines the terminus of a chain of trips, and that chain of trips is considered a tour. The rationale and analyses of the application of this dwell-time rule is explored in this paper. Finally, using this definition, the 1995 NPTS and the 2001 NHTS trip data have collapsed into tour-level files, which are available to academics, researchers, and policy makers for further research. Of course, any researcher can use the full trip file to assess other definitions of trip chains.

A Short History of Purpose Coding

The NPTS/NHTS data series is the only source of national data on the distribution of trips and travel by purpose and is widely used for that topic. Over the course of the series, trip-purpose coding has changed--causing some complications for data analysts.

For the 1969, 1977, 1983 and 1990 NPTSs, trips to return home trip were assigned to the purpose of the outgoing trip. If there was more than one outgoing trip before a return home, a set of criteria was developed and employed to determine which purpose to use for the return home. This was all completed during the actual interview. In all cases, work trips got priority in the coding scheme. This was done in deference to the traditional emphasis on travel to and from work as part of the transportation planning process.

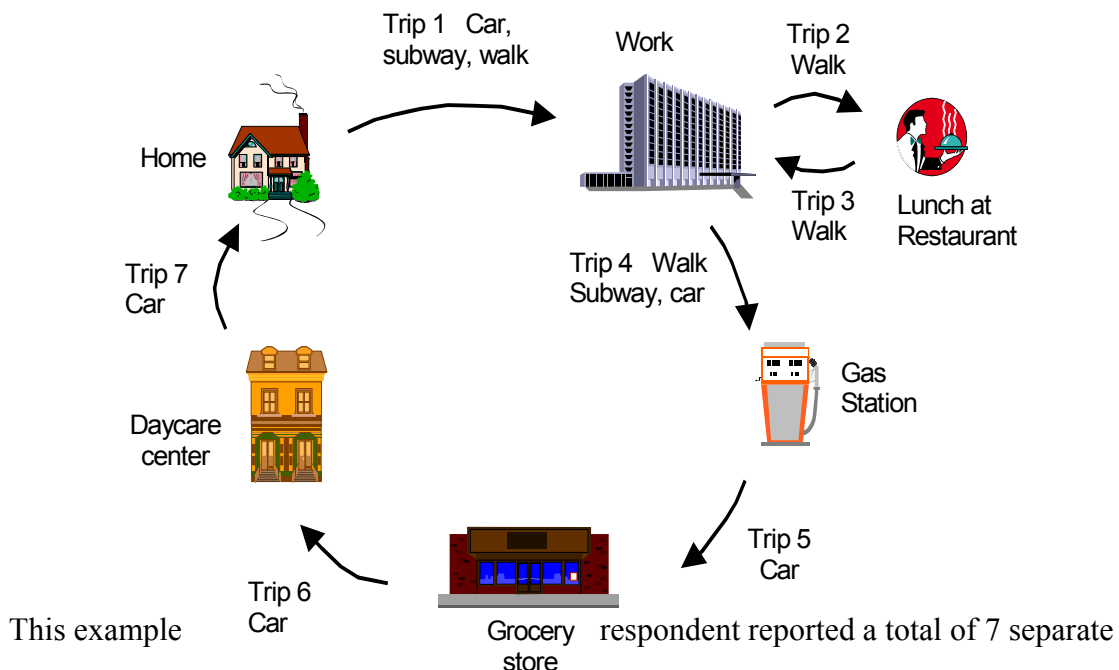
When the 1990 NPTS data was being analyzed, the topic of trip chaining had become more prominent along with the importance of examining each respondent’s movements from place to place throughout the day to allow us to examine trip chaining. Thus, in the 1995 and 2001 surveys, data on each trip was collected as individual segments from point to point. That solved one problem and created two others. First, the trip purpose data

were no longer comparable over time, and second, the 1995 data showed about 35 percent of all trips and travel for “Return Home”, which was not helpful in descriptive or analytical terms. Therefore, the new trip purposes were recoded into the old scheme, and the resulting variable was called WHYTRP90. Of course, assumptions about the main purpose for the trip had to be made, but the recoding of trip purposes (WHYTRP90) allowed historical analysis.

In the original trip coding scheme used in the early surveys, and in the recode to WHYTRP90 used in the 1995 and 2001 data, a dwell-time limit was never established. However, in the definition of a trip chain a dwell time of 30 minutes or more was assigned to the purpose of that stop. So, if a respondent makes several short stops on her way home from work, it met our definition of a tour (a series of trips that are chained together). However, if a respondent makes on short stop, say 10 minutes, then goes someplace else and stays an hour, the chain has been broken, and the trip to the hour-long dwell-time destination is no longer considered to be part of a work-to-home chain. It is considered to be an independent activity.

Trips, Chains and Tours

The 2001 National Household Travel Survey is an inventory of each individual movement by all members of each sampled household from one address to another (a trip). Each trip is recorded, with mode, purpose at destination address, and number of people on the trip, the departure and arrival times, trip duration, the household vehicle used, and other pertinent information about the trip. An example of one person’s trip movements on the travel day are shown below:



trips, according to the NHTS trip definition. Trip 1 was clearly a trip to work, but the trip from work to home was interspersed with stops for other purposes. The non-work stops along what is primarily a tour between the residence and the workplace complicates the analysis of the work commute. The miles and minutes of travel between the grocery store and the day care, for instance, are assigned to a non-work trip purpose, so if we tried to directly measure the miles and minutes workers spend commuting, these trips would not be included.

In the 2001 NHTS, (including all stops of any dwell time) nearly 20 percent of the home-to-work travel has non-work segments and 30 percent of the work-to-home travel has non-work segments. These imbedded trips within the commute limit our ability to estimate commute miles and minutes definitively, since regular stops within the commute (such as dropping children at school) may significantly affect route choice, time of day, trip length, and overall travel time.

The following sections describe the process to develop the selected tour definitions, showing several steps that were analyzed before developing this operational definition of trip chains and tours.

A few definitions used in describing this trip chaining process:

Anchor	A primary or substantial trip destination.
Direct Trip	A trip that travels directly between two anchor destinations, such as a trip from home to work
Chain	A series of short trips linked together between anchor destinations, such as a trip that leaves home, stops to drop a passenger, stops for coffee, and continues to work.
Intervening Stop	The stops associated with chained trips.
Tour	Total travel between two anchor destinations, such as home and work, including both direct trips and chained trips with intervening stops. Note that it is possible to have the two anchor destinations be the same location, as in a home-to-home or work-to-work tour.

Description of the Process

Much of the preliminary analysis to establish the logic for coding was conducted on the 2001 NHTS Public-Use file (Jan. 2004--the most recent file available), and after the logic was established the rules were applied to the 1995 NPTS.

All travelers, regardless of age or mode of travel were included: for example, 31 percent of travelers of all ages made a home-to-work tour, but 58 percent of workers made a

home-to-work tour on the travel day. Although trip chaining is often associated with vehicle trips, the analysis and files include all person trips, vehicle driver, passenger, transit, walk, and bike.

Step 1. Creating Tours from the Trip File without Regard to Dwell Time

The first step in the process was to link all the trips in the 2001 NHTS public use trip file into tours anchored by Home, Work, or some other place, regardless of dwell time. Home and Work were the primary anchors at this stage. For a respondent who did not report a work trip on the travel day, all the trips made from the time the respondent left home until he or she returned home were included as one “Home-to-Home” tour. If that same respondent left home and made a series of trips and again returned home, he or she would have two Home-to-Home tours.

Trips with missing start times could not be included in this process--659 trips (.01 percent of the 642,292 recorded trips) had missing values for start time in 2001 NHTS. In addition, a few trips were reported that could not be anchored on both ends to either home or work during the travel day—people started the travel day away from home, left work and did not return home, or were away from home throughout the day. A total of 38,525 trips (6 percent of the 641,633 remaining trips) were trips without a home or work anchor (shown as “Other” in Table 1).

The sequence of trips for each individual was examined and marked as to whether the sequence began at home and ended at home (70.4 percent of the trips), began at home and ended at work (9.3 percent of trips), began at work and ended at work (3.4 percent of trips) or began at work and ended at home (10.9 percent of trips).

Table 1 - Number and Percent of Trips by Anchor Type, 2001 NHTS (n=641,633 trips)

From ↓	To →	Home		Work		Other	
Home		451,761	70.4%	59,716	9.3%	13,442	2.1%
Work		70,113	10.9%	21,518	3.4%	932	0.1%
Other		14,098	2.2%	7,865	1.2%	2,188	0.3%

Table 2 shows the distribution of tours by anchor type without limits on the dwell time of the intervening stop. This process of allocating trips into tours anchored by home, work, or other resulted in 287,985 tours.

Table 2 - Number and Percent of Tours by Anchor Type, 2001 NHTS (n=287,985 tours)

From ↓	To →	Home		Work		Other	
Home		167,244	58.1%	47,640	16.5%	6,687	2.3%
Work		47,414	16.5%	9,817	3.4%	414	0.1%
Other		4,594	1.6%	1,756	0.6%	2,419	0.8%

Table 3 shows the average number of intervening trips made within each tour type; that is beyond the direct trip from origin to destination. For example, if the number of trips in home-to-work tours (59,716 trips) were divided by the number of tours in that tour type (47,640 tours) the result is 1.25. If we subtract 1 for the destination at work being counted we calculate 0.25 intervening trips per home-to-work tour.

Table 3 - Average Number of Stops Within Tour by Anchor Type, 2001 NHTS

From ↓	To →	Home	Work	Other
Home		1.7	0.3	1.0
Work		0.5	1.2	1.3
Other		2.1	0.3	2.3

Step 2. Defining the Dwell Time Rule

After bundling the trip files into different dwell-time categories, we tested the effect of different dwell times on the number and percent of trips by type of tour. Table 4 shows the number of trips included with a 90-minute dwell time, Table 5 shows a 60-minute dwell time and Table 6 shows the number of trip included with a 30-minute dwell time cut-off.

Decreasing the dwell-time limits moved more trips into the “Other” tour type; for example, if a person left work to go out to eat (spending one hour and 15 minutes) and continued to home, with a 90-minute dwell time rule that chained trip would be classified a Work-to-Home tour, but with a 60 minute dwell time rule that chained trip would be

considered two tours—one tour classified as Work-to-Other and one from Other-to-Home.

Table 4 – Number and Percent of Trips by Anchor Type with 90-Minute Dwell Time

From ↓	To →	Home		Work		Other	
Home		263,471	41.0%	57,000	8.9%	98,561	15.3%
Work		60,776	9.5%	21,518	3.4%	6,458	1.0%
Other		105,324	16.4%	18,846	2.9%	26,501	4.1%

Table 5 - Number and Percent of Trips by Anchor Type with 60-Minute Dwell Time

From ↓	To →	Home		Work		Other	
Home		202,526	31.5%	55,643	8.7%	123,812	19.3%
Work		70,113	10.9%	21,518	3.4%	932	0.1%
Other		132,463	20.6%	6,056	0.9%	38,035	5.9%

Table 6 - Number and Percent of Trips by Anchor Type with 30-Minute Dwell Time

From ↓	To →	Home		Work		Other	
Home		121,546	18.9%	53,492	8.3%	154,425	24.0%
Work		51,064	8.0%	11,638	1.8%	13,571	2.1%
Other		162,060	25.2%	64,340	10.0%	9,497	1.5%

Figure 1 shows the percent of trips that changed category with the stricter dwell-time rules. The effect, as stated previously, was to move more trips into the ‘Other’ category. Home-to-Work and Work-to-Home tours lost just a small percent of trips when the dwell-time rule was set at 30 minutes or less.

The logic for developing tours where the two anchors are the same location (Home-to-Home and Work-to-Work) diverged from the logic for Home-to-Work and Work-to-Home tours. Home-to-Home and Work-to-Work tours were a separate group for analysis. For example, if there was only one outbound stop on a home-to-home tour it was considered a direct trip, and where the anchor is the same location two stops were required to be considered part of a chain.

Figure 1

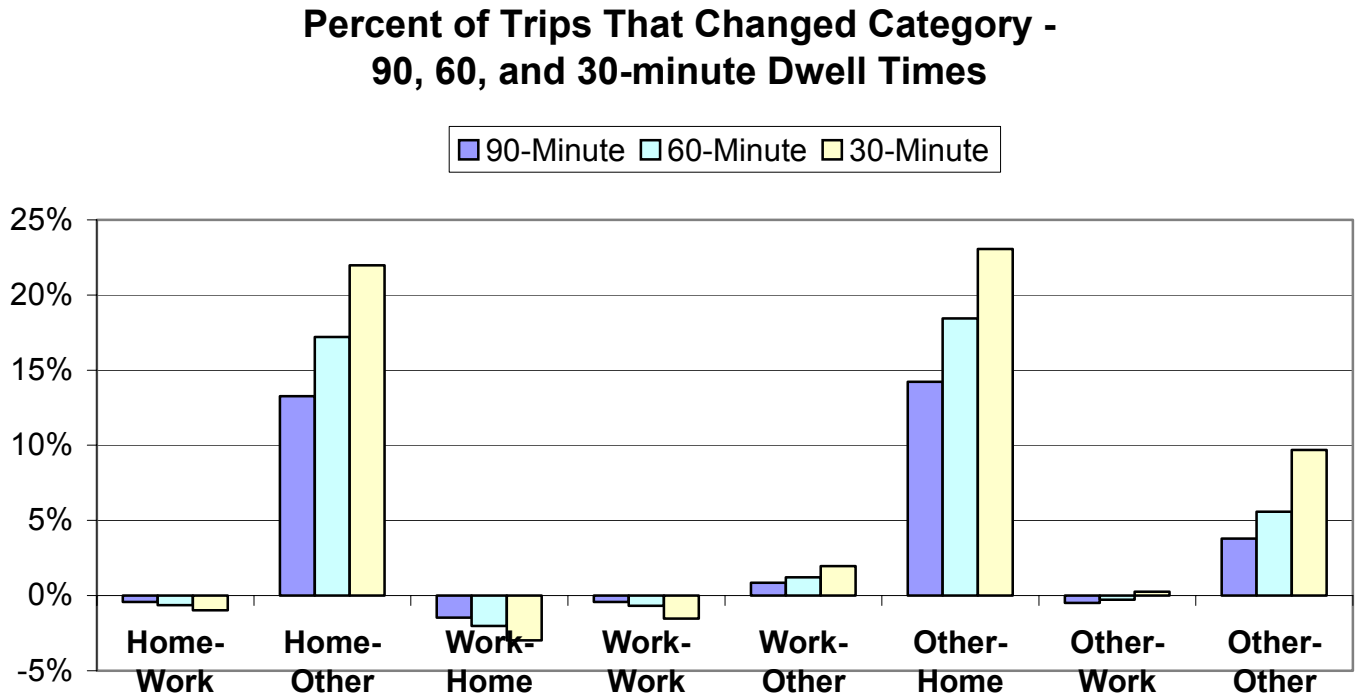


Figure 2 and Figure 3 show the median and mean dwell time for all stops for selected detailed purposes for home-to-work tours and work-to-home tours respectively for the 2001 NHTS. The dark line shows the 30-minute cut-off used to determine which types of trips might be considered intervening stops on larger tours, and which considered substantive trip destinations of their own.

Stops for common incidental purposes on the way to or from work, such as pick-up or drop-off a passenger, stop at daycare, buy gas and coffee, and get a meal, all mean dwell times well under the 30-minute limit. At the other end of the spectrum what were considered substantive trip activities such as eating out, going to the gym, or attending meetings had longer mean dwell times and far fewer of these trips fell under the 30-minute dwell time limit.

Figure 2-

Dwell Time at Stops - Home to Work Tours

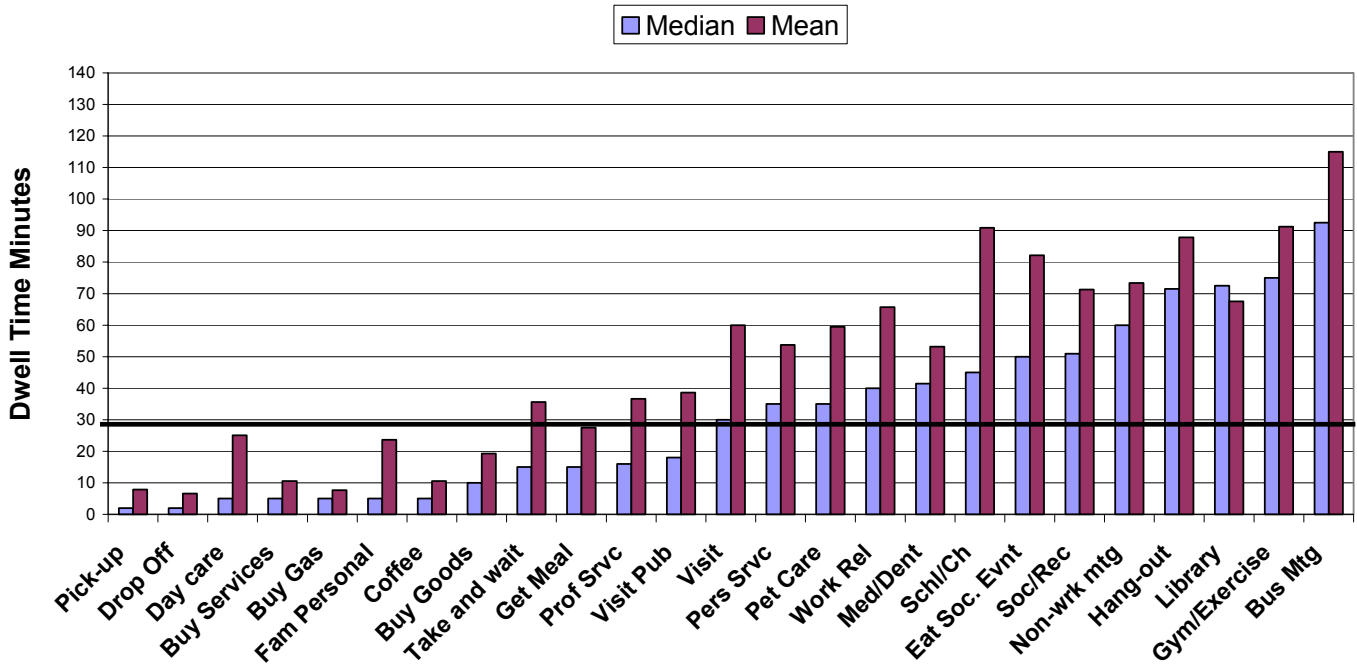
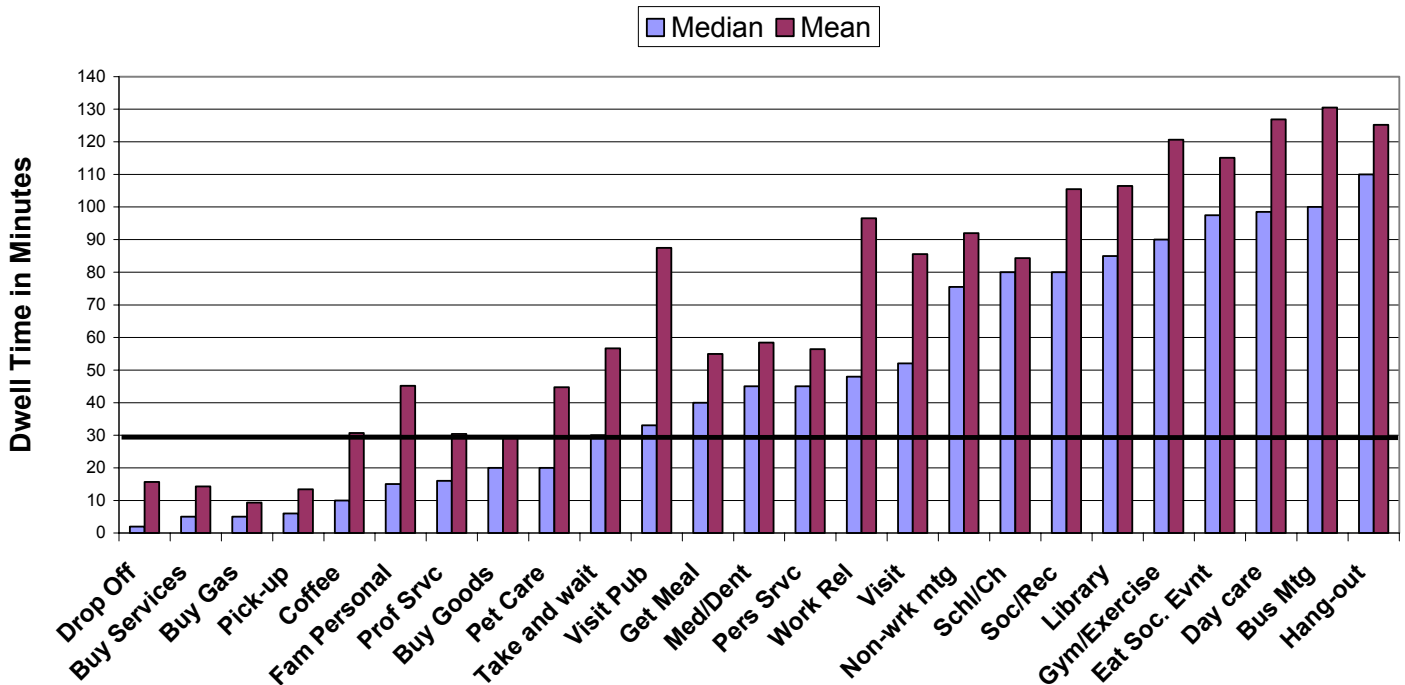


Figure 3 -

Dwell Time at Stops - Work to Home Tours



As a result of these analyses, and in conference with a team of advisors, the FHWA decided to select trips that were interrupted by a stop of 30 minutes or less, regardless of purpose, as part of a tour—any stop of 31 minutes or more was considered a substantive trip destination. This decision allocated the trips that were 31 minutes or more at any destination into different tour categories.

The result is that trips that originated at home and were destined to work but had one or more stop of 31 minutes or more were termed home-to-other. Similarly, trips that originated at work and eventually ended at home but had one or more stops of 31 minutes or more were termed work-to-other.

Step 3. Collapsing the Trip Files and Analyzing Tours

The 1995 NPTS contains data for people ages 5 and over, while the 2001 NHTS includes people of all ages. Since workers are primarily 16 years and older, and to facilitate comparisons between the two data sets, the following analysis concerning home-to-work and work-to-home includes people ages 16 and over.

The tour-based analysis is simply a different way of looking at travel patterns. All trips are in tours, whether direct or chained, the tour-based file simply allocates the purpose of the trips differently than the previous method (WHYTRP90).

With a rule in place allowing only stops of 30 minutes or less to be considered part of home-to-work and work-to-home tours, the analysis turned to looking directly at the effect of this definition on estimates of commute miles and minutes.

The falling share of travel that is directly attributed to work has concerned planners and policy-makers. The chained trip file captures more trips into the commute—but fewer miles than the earlier method. Table 7 and 8 and Figures 4 and 5 show the effect of using tour-level analysis on trips and miles for 1995 and 2001, all interviewed persons and those 16 and older.

Table 7 – Percent of Person Trips for Commuting

Person Trips in Millions					
Person Trips by 16+		WhyTrp90	ChnTrp	% WhyTrp90	% ChnTrp
1995	Person Trips (5+)	379,000	379,000	100.0%	100.0%
	To/From Work	63,500	65,100	16.8%	17.2%
2001	Person Trips (all ages)	322,000	322,000	100.0%	100.0%
	To/From Work	59,700	63,000	18.5%	19.6%

Figure 4

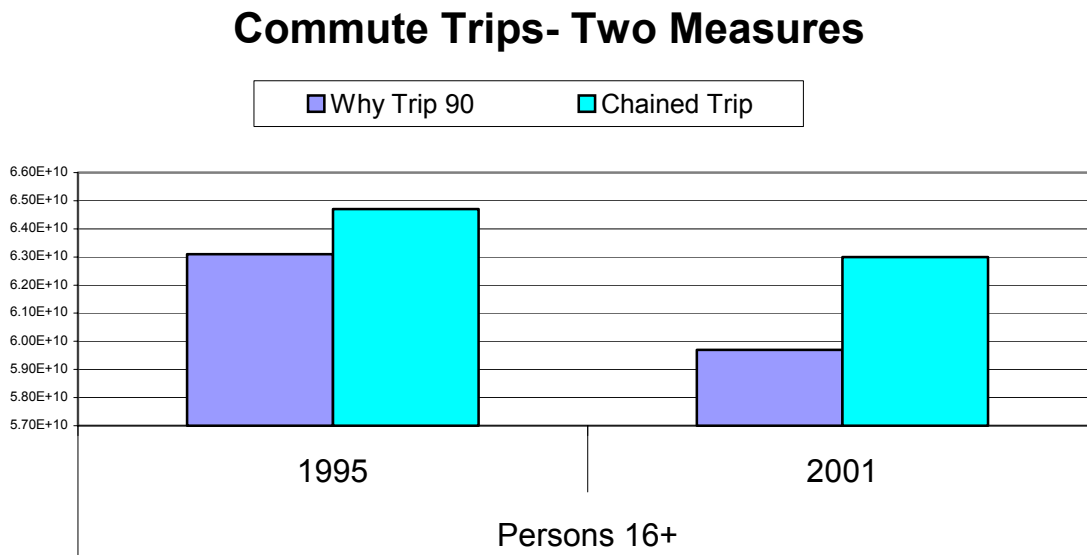
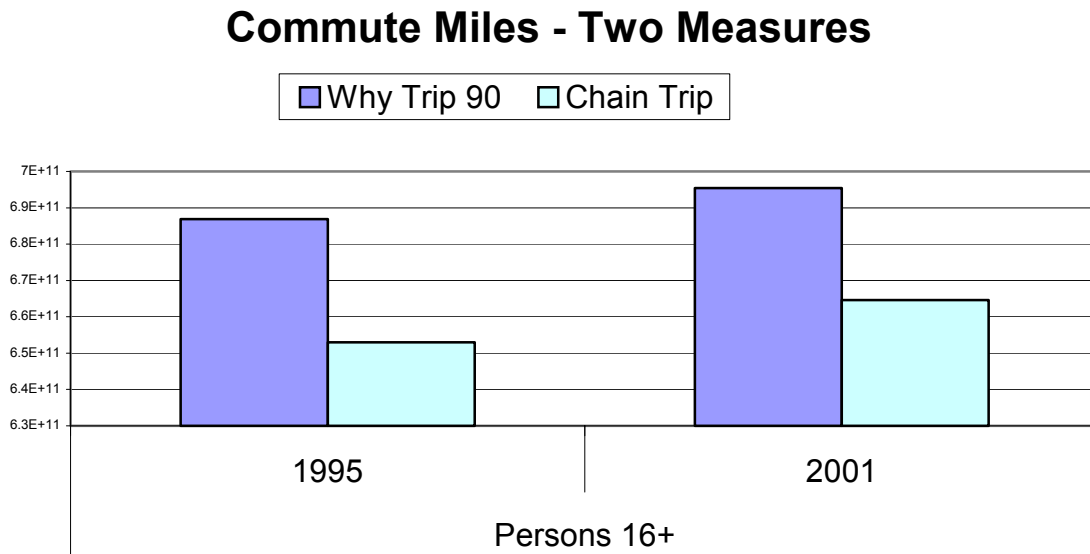


Table 8 – Percent of Person Miles of Travel for Commuting

Person Miles in Billions					
Person Trips by 16+		WhyTrp90	ChnTrp	% WhyTrp90	% ChnTrp
1995	Person Miles (16+)	3,017	3,017	100.0%	100.0%
	To/From Work	687	653	22.8%	21.6%
2001	Person Miles (16+)	3,132	3,132	100.0%	100.0%
	To/From Work	695	665	22.2%	21.2%

Figure 5



Although the total number of POV miles decreased when looking at commute tours with only a 30-minute dwell time, the tour file captures more transit and walk miles than the previous method of purpose coding (WHYTRP90).

Figure 6

POV Weighted Miles for Work, 16+

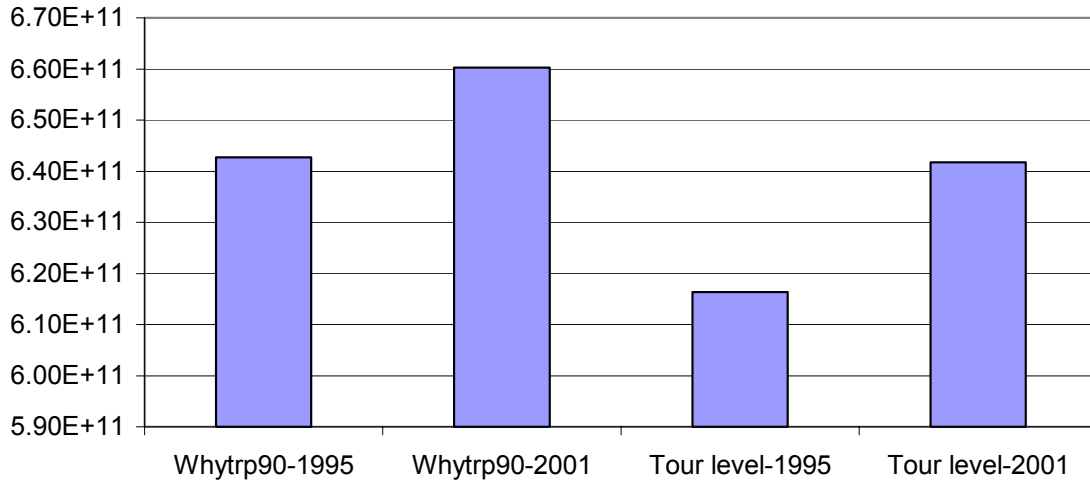


Figure 7

Transit Weighted Miles for Work, 16+

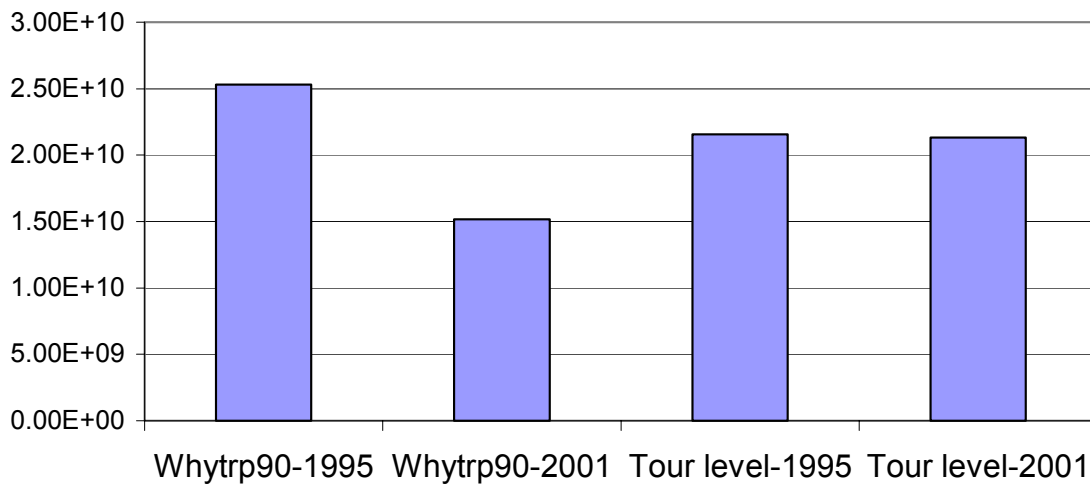
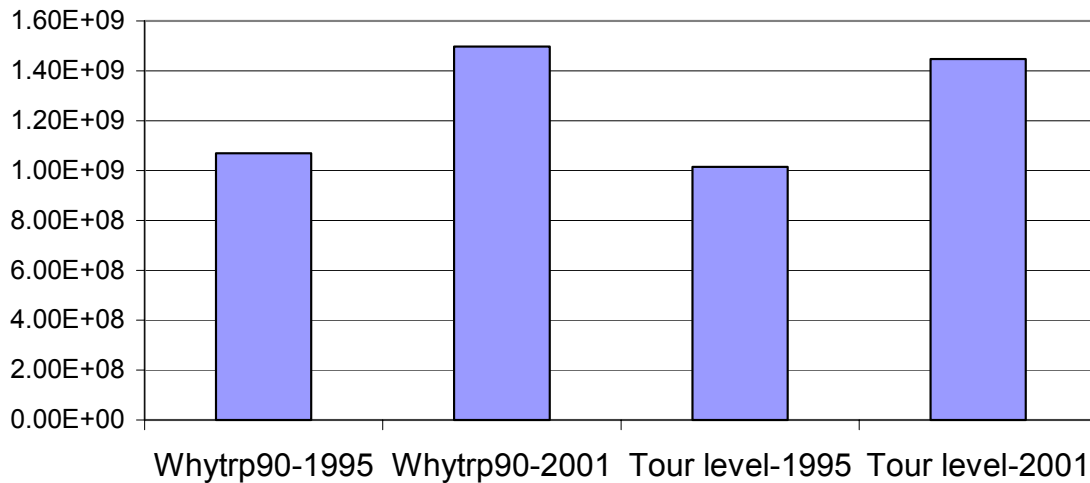


Figure 8

Walk Weighted Miles for Work, 16+



Conclusion

The fact that the tour-level analysis captures more trips and slightly fewer miles than in the previous method of assigning trips and miles to purposes (Whytrp90) means that the trips included in the tours for work are in fact incidental trips made along the way. Including segments in the trip chain captured more transit and walk miles as part of commuting behavior.

The national data does not have trip ends geocoded, but with the robust add-on sample in 2001 the location and route effects of these incidental stops could be a very interesting area of research.

The trip tour file is a powerful tool for analyzing and understanding commute behavior and changes in travel patterns. The files and documentation are available and the hope is that researchers and policy makers will make full use and offer further insights. Of course, researchers who want to explore other definitions of a trip chain have the full trip file from the NHTS.