A study of tour formation: pre-, during, and post-recession analysis

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Abstract

This study examines changes in activity-travel patterns of employed people during a recession by using a tour-based representation of the activity-based approach. The term *tour* is defined as a sequence of trips and activities that begins and ends at home and contains at least one non-home activity. Tours are classified based on the presence of work and/or non-work activities. We are interested in investigating how a recession can affect an individual's tour choices. We developed a rigorous methodological framework by using multi-group structural equation modeling (SEM) to analyze changes in tour choice. In particular, we developed a causal structure conceptualsizing the interrelationships among socio-demographic and economic characteristics, activity-travel participation, and the choice of various work and non-work tours. Using data from the American Time Use Survey (ATUS), the study found that activity-travel relationships and their role in tour choice differed in the recession year (2009) compared to pre- and post-recession years (2009 and 2012, respectively). By analyzing temporal changes in causal structure, we identified four sub-trend groups defined by: (1) norms that did not change in pre-, during, and post-recession years, (2) norms that changed during the recession but returned to the *old norm*, (3) norms that changed during the recession and were maintained as *new norm*, and finally (4) 2006 norms that did not change during the 2009 recession but changed after the recession. Via analysis of multiple group SEM, we identified instances of each of these cases and provided potential rationales in the context of how a recession can influence norms and thus can affect activity-travel behavior.

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Introduction

The technology, climate, economic, and demographic changes currently evident portend future change in travel behavior. Despite prior stability of automobile ownership and use patterns, these changes likely will have direct impacts on activity-travel patterns. To analyze such change requires before and after data, which can be difficult to obtain when the drivers of change are not within our control. The 2009 recession provided a significant but relatively short tenure economic change, and the American Time Use Survey (ATUS) provided data before, during, and after that recession.

Our research motivation was to examine changes in travel behavior when an external change occurs. Prior studies considered recession impacts using ATUS data (Aguiar et al. 2013; Berik and Kongar 2013) but these reflected only time allocation behavior and not travel behavior. Studies on changes in travel behavior due to recessions are limited. These studies focused on various changes during recessions, such as automotive travel behavior (Thomas et al. 2015; Blumenberg et al. 2016), travel expenditures (Thakuriah and Mallon-Keita 2014; Keita and Tilahun 2017), traffic fatalities (Noland and Zhou 2017), and millennial activity-travel behavior (Garikapati et al. 2016). However, these studies did not consider changes in travel behavior from an activity-based approach.

The activity-based approach is widely used to analyze complex travel behavior. The fundamental tenet of this approach is that travel decisions are driven by a collection of activities that form an agenda for participation and, therefore, travel cannot be properly analyzed on an individual trip basis. The process of assembling a travel-activity pattern and the choice attributes of each component can only be understood within the context of the entire agenda (McNally and Rindt 2007). In this work, we utilized time use data to analyze changes in travel behavior during a recession compared to that before and after in a holistic manner via an activity-based approach. This approach uses *tours* as a basic unit of analysis, with a tour being defined as a sequence of trips and activities that begin and end at the same location, in our case at home.

While ATUS time use data provides rich before and after data, it is limited in that it is a cross-sectional survey of only a single household member. To narrow our focus, we examined the changes in travel behavior during a recession for only employed persons. Granted, individuals that maintain employment throughout an economic recession were less impacted, but this choice allows us to examine the relationships between changes in travel behavior and the changes in employment type (for example, full-time, part-time, or multiple jobs). Our second interest narrowed travel behavior to tour formation. Our particular research questions focused on how time is allocated to different activity demands at different times of a day, how are these activity demands allocated to out-of-home travel tours, and how does the imposition of an external change affect how people organize their daily activity-travel patterns.

The next section describes relevant studies regarding recessions. We then define the representation of complex travel behavior in the form of tour types. The time-use data and our sample are then described followed by an overview of the selected modeling methodology, multiple group structural equation models (SEM). Model results are then presented followed by a summary of the implications for changes in travel behavior in the face of an external change, in this case, the 2009 recession. Last, conclusions and potential implications for policy are provided.

Literature review

This section provides an overview of previous research studies relevant to this work with a particular focus on time-use and travel behavior related studies considering the recession.

The 2007–09 recession and its notable impacts

The most recent recession began in December 2007 and continued for the next 2 years (National Bureau of Economic Research 2018). A recession is in general characterized by a slowdown in the national economy, a downturn in the business cycle, and a decrease in the amount of production and sales of goods and services (Bureau of Labor Statistics 2012). According to the Bureau of Labor Statistics (2012), the national unemployment rate was 5% at the end of 2007 but this doubled over the next 2 years (to 10% in October 2009). Recession caused a reduction in not only employment status but also of workers' hours. It was reported that the aggregate work hours (product of total number of employees and average weekly hours) dropped by 7.7% between December 2007 to December 2010 (Kroll 2011). Moreover, during the recession, the number of individuals who were employed part-time for economic reasons (also known as involuntary part-time workers) increased dramatically (Borbely 2009). The result was that workers often started to find and work more than one job (Hipple 2010).

In addition to employment, notable changes occurred in consumers' purchasing behavior during the recession, such as in the housing sector. Homeownership rates dropped in conjunction with the depreciation in housing prices and increases in home foreclosures. Winkler (2013) reported that from 2007 to 2010, housing prices fell about 13% in the US whereas the home foreclosure rate increased from 0.87 to 3.26%. Another change in consumer purchasing behavior was observed in the auto sector, which can be characterized by lower car ownerships, delayed purchase of additional vehicles (new or used) when selling, increased number of zero-car households and therefore reduced transportation expenditures during the recession (Thakuriah and Mallon-Keita 2014).

Changes in time use and travel behavior during the recession

During the recession, changes occurred in time allocation behavior. By using the 2003–2010 ATUS data, Aguiar et al. (2013) identified that household production and leisure activities mostly absorbed the reduced work hours during the recession. According to their findings, 30% of the foregone work hours were substituted by core household production activities, such as cooking and cleaning and 50% was substituted by sleeping and watching television. A significant difference in time allocation behavior between men and women was also observed. For example, reduced work hours were allocated more to core household activities for women whereas TV watching and education activity increased for men.

Using the same dataset, Berik and Kongar (2013) found that the gender gap between married mothers and fathers narrowed in both paid and unpaid work hours during the recession as mothers substituted paid work for unpaid work and fathers' paid work hours were reduced. Krueger and Mueller (2012) investigated the relationship between unemployment and well-being issues. They found that although unemployed people spent more time in leisure activities than employed people during the recession, they enjoyed those activities to a lesser degree by reporting a higher level of sadness than their employed counterparts.

Thus, the effects of recession are predominantly considered from the perspective of time allocation behavior in social science literature. These studies have not addressed the recession effects from a travel behavior perspective.

Several studies in the transportation planning field observed recession effects on travel behavior. McCahill (2017) examined that total domestic vehicle miles traveled (VMT) peaked in 2007, dropping significantly until 2014. Per capita VMT decreased by about 7% in this period despite a general recovery in the economy. Furthermore, public transit ridership in many metropolitan areas in the US dropped significantly, a trend that unlike VMT did not return to pre-recession levels (per capita transit use has dropped about 9.7% since 2014) (The Transport Politic 2018). Other studies also considered recession impacts on public transit but mostly in the context of European countries (Efthymiou et al. 2018; Ulfarsson et al. 2015; Cascajo et al. 2018).

Various studies reported reduced travel expenditures during the recession (Thakuriah and Mallon-Keita 2014; Paulin 2012). Since income affects travel behavior, the decline in household income due to the economic downturn leads to a reduction in travel spending, which resulted in reduced mobility and activity participation, particularly in female-headed and low-income households (Keita and Tilahun 2017; Thomas et al. 2015). The decline in household income, on the other hand, caused a reduction in trip-making and consequently a reduction in traffic fatalities (Noland and Zhou 2017; Maheshri and Winston 2016).

The 2007–09 recession had an impact on the travel behavior of millennials. Garikapati et al. (2016) observed a lag among millennials in adopting the activity-travel pattern of their predecessor generation, partially ascribed to the lingering effects of the great recession. Blumenberg et al. (2012) examined changes in the travel behavior of youths and adults during the recession. They found that unemployment was considerably higher among youths than adults, which resulted in a higher decline in work-related travel as well as travel for other purposes for youths. Since it was difficult for them to own and operate automobiles due to the economic crisis, they relied more on alternative modes, such as public transit and walking for travel.

This study in the context of previous studies

Previous literature in social science focused on the changes in time allocation behavior during the recession but provided limited consideration on travel to various activities. Research that focused on changes in travel behavior due to an economic crisis explored changes in travel in the context of vehicle miles traveled, travel expenditure, transit usage, and traffic fatalities. These findings, however, were based primarily on univariate statistical analysis and did not consider changes in activity-travel behavior from an activity-based perspective. In particular, they did not take into account whether people changed their sequence of activities and trips (tour) during a recession to gain efficiency in activity participation (for example, by performing multiple out-of-home activities within a single tour or mixing non-work activities with work instead of making separate non-work tours).

This current study, on the other hand, explores such changes in tour patterns for employed people by using a multivariate statistical technique. A multiple group structural equation modeling (SEM) was developed that facilitated the investigation of the invariance in causal structures between the pre, during, and post-recession years. More specifically, this approach enabled the examination of whether the choice of tours (work and non-work) varied during the recession due to changes in socio-economic characteristics (e.g., nature of work) and time spent in activity participation. Multiple-group SEM has been used in

travel behavior research to identify differences across various transport user groups, how-ever, little is known about the use of this technique to explore the temporal differences in the conceptualized causal structure proposed herein.

To develop this model, the American Time Use Survey (ATUS) data was used. ATUS is the most reliable national-level time-use data that has been widely used in the social science literature to analyze the time-use behavior of individuals (e.g. Robinson and Mar-tin 2010; Mastracci 2013; Anand and Ben-Shalom 2014). This data has also been used in travel behavior studies to examine activity-travel behavior of particular groups (Bernardo et al. 2015; Fan 2017; Garikapati et al. 2016; Gimenez-Nadal et al. 2018) or to connect activity-travel time use with well-being issues (Archer et al. 2013; Stone and Schneider 2016; Morris 2015). From an activity-based perspective, researchers have used this data to model activity choice, time-use, joint-activity participation, and activity scheduling issues (Ferdous et al. 2010; Srinivasan and Bhat 2008; Langerudi et al. 2016). However, to the best of our knowledge, this study is the first to use ATUS data to provide a tour-based representation of activity-based approach that facilitates analysis of how employed people organize their daily activity-travel patterns (i.e., tours) over the travel day.

Tour formation of employed people

This study considers home-based tours: those that both start and end at home. A simple tour starts and ends at home and includes a *single* non-home activity. If the activity per-formed is work, then it is a *simple work* tour; for any other activity type, it is *simple non-work* tour. On the other hand, a tour containing more than one non-home activity location is defined as a *complex* tour. If all non-home activities are work, then the tour is a *complex work* tour; if all the non-home activities are non-work, then the tour is a *complex non-work* tour. Complex tours can also combine work and non-work activities in the same tour, in which case they are *work-nonwork mixed* tours. Since the number of complex work tours is found to be very small in our dataset (less than 2% of all tours), we combine simple and complex work tours into a single category as *work-only* tours, which effectively gives us four types of tours: work-only, simple non-work, complex non-work, and work-nonwork mixed [similar to the classification used by Golob (2000)]. Figure 1 shows different types of simple and complex tours.

Since work activities are less flexible, employed people with a non-home work activ-ity typically make at least one work tour (either work-only or work-nonwork mixed) and then align their non-work activities with respect to that tour. Non-work activities can be performed as separate non-work tours or as a part of a work-nonwork mixed tour, in any of five ways:

1. "before work:" non-work activities are performed on a non-work (simple or complex) tour prior to starting the first work tour of the day;
2. "way to work:" non-work activities are performed on the way to work;
3. "during work:" non-work activities are performed outside the workplace but the indi-vidual returned to the workplace after completing them;
4. "way to home:" non-work activities are performed on the way home from work;
5. "after work:" non-work activities are performed by making separate non-work tours after returning home from work.
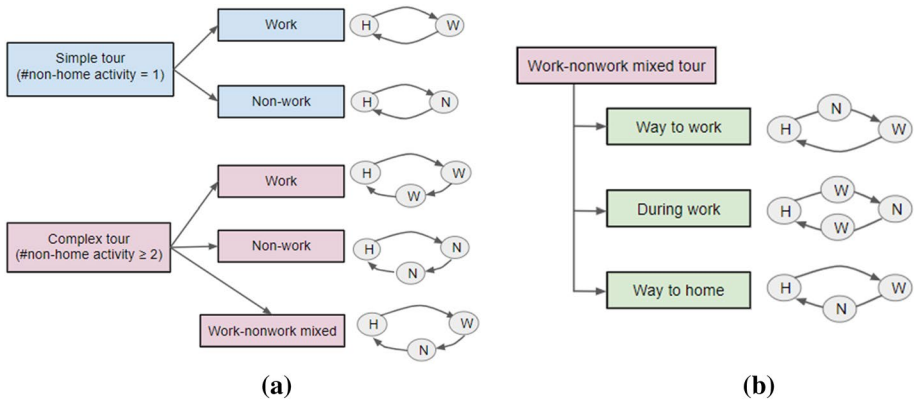
Fig. 1 Defining simple and complex tours

This partition of non-work activities into five timeslots also appears in prior studies (Damm 1982; Bhat and Singh 2000). For people who work only at home and do not make any work tours, we considered the longest work duration activity as a reference point and distribute 'before' and 'after' out-of-home non-work activities accordingly.

Data and sample

The American time use survey data and sample

We used the American Time Use Survey (ATUS) from 2006, 2009, and 2012 for pre-, during, and post-recession years, respectively. Defined in economic terms, the recession started in December 2007 and continued through June 2009 (National Bureau of Economic Research 2018). There are several reasons that we considered the full year of 2009 as the peak recession year. First, although the economic downturn ended in the middle of 2009, associated transportation impacts changed more slowly and lasted longer, and thus were expected to extend beyond the year 2009. Second, this selection enables us to explore the seasonal effects on tour choice in a whole year in our model. Finally, the choice is consistent with prior studies (Aguiar et al. 2013; Berik and Kongar 2013). The before and after recession years were chosen so that they are not too far removed from the recession year so as to be affected by other trends.

ATUS surveys are conducted every year facilitating the pooling of data for the pre-, during, and post-recession years, each 3 years apart. ATUS surveys time use information for detailed activity categories (e.g., work, socializing, traveling) performed by individuals for one complete day (from 4 am to 4 am the next day). ATUS data also contain socio-demographic information for the household respondent and location information defining the geographical area in which the respondent resides (obtained by interfacing with Current Population Survey data). Our target group is defined as employed adults who on the survey day worked, made at least one home-based tour, made not more than 10 trips, and did not use transit for any trips (these individuals were omitted due to low sample size). After removing the missing observations from data, the result was a total of 8251 respondents, with 2712, 2723, and 2816 for the years 2006, 2009, and 2012, respectively.

Data processing and tour construction

To construct tours, we extracted activities for each person in the study group (from the "atusact" data table) and coded the activity based on four types: W to indicate work, N for non-work, T for travel and H for staying at home (i.e., activities performed at home). In the dataset, each activity is recorded with the activity type/purpose (coded with a three-level hierarchy), start time, end time, duration, location, and other relevant information. The activities are arranged in ascending order of their start times starting from 4:00 am until 4:00 am the following day. With this coding, the activity sequence of an individual can be expressed as a sequence of four symbols (H, T, W, N), which we call an *activity string*. For example, HTNNTWTHTNTH is an activity string of an individual that reads as follows: the individual was at home at the beginning of the day and made a trip to a place to do two non-work activities back to back and then traveled to work; after work, the individual traveled home, completing a tour. This individual leaves home on a second tour to perform a non-work activity and then returns home. This individual made two tours: the first being a complex tour (work-nonwork mixed) and the second being a simple non-work tour. Note that each activity string also maintains details of the activities performed within that string (duration, purpose codes, location, start time, end time, etc.) stored in separate data structures. For a given activity string, we split the entire string into segments each of which starts and ends with H (each segment effectively corresponds to a tour). Then, we determined which of the four tour types the segment represents.

Activity-travel time use during the recession

We attempted to determine in which types of activity and travel people allocated time differently in the recession year than the pre- and post-recession years. To do so, *Kruskal–Wallis* non-parametric tests (with *p-value* < 0.1) were conducted. Four distinct categories of significant *changes* in activity-travel durations were identified after this difference test: (1) 2006 durations that changed in 2009 but returned to the 'old duration' in 2012 (2) 2006 durations that changed in 2009 and changes were maintained in 2012 as a 'new duration' (3) 2006 durations that did not change in 2009 but changes occurred after 2009, and (4) 2006 durations that changed in 2009 and changes were continued in 2012.

Figure 2 shows these four categories of change in mean activity durations. The vertical axis represents the change in mean activity durations in 2006 and 2012 with respect to the 2009 mean duration. For each activity type, the percentage in parentheses is the portion of individuals who participated in that activity calculated as an average over the 3 years. In this figure maintenance activities include household activities, childcare, personal services, consumer purchases, and religious activities whereas taking meals, socializing, relaxing, leisure, sports, exercise, recreation, and phone calls are considered as discretionary activities.

In Fig. 2a, it can be observed that the average duration of work outside home decreased significantly by around 5% in the recession year and again increased by 4% in the post-recession year. As discussed earlier, previous studies also found that the 2007–09 recession caused a decline in work hours (Kroll 2011; Goodman and Mance 2011). In contrast to the reduction in work hours, we found that the average duration of total non-work activities, particularly the duration of maintenance activities inside home increased significantly during the recession, which again dropped after the recession (Krueger and Mueller 2012).
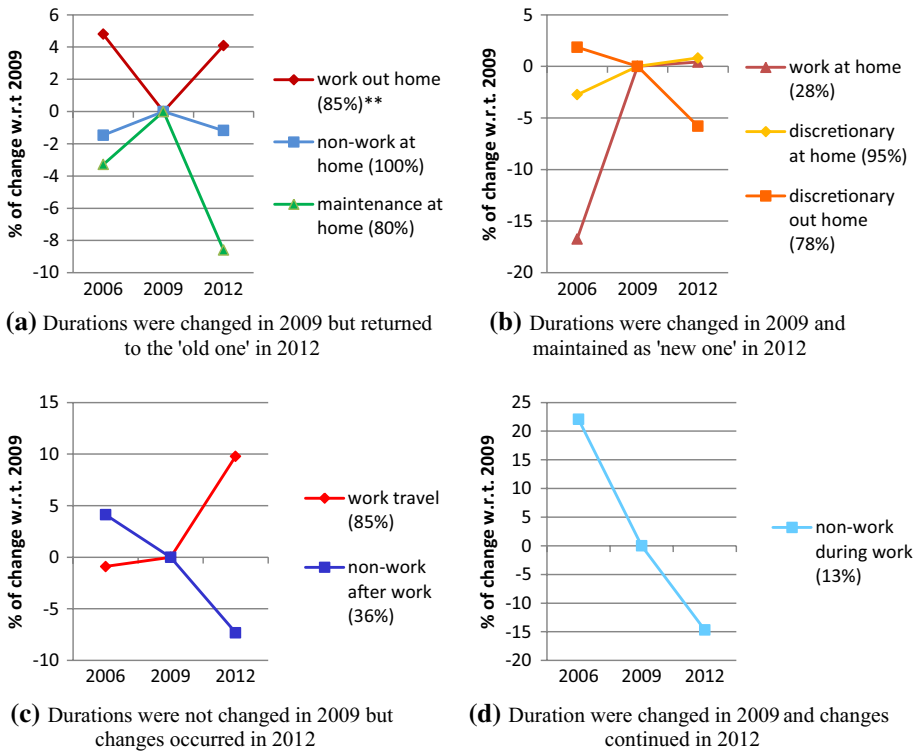
(a) Durations were changed in 2009 but returned to the 'old one' in 2012

(b) Durations were changed in 2009 and maintained as 'new one' in 2012

(c) Durations were not changed in 2009 but changes occurred in 2012

(d) Duration were changed in 2009 and changes continued in 2012

Fig. 2 Changes in mean activity durations in 2006 and 2012 with respect to 2009. ** The percentage in parentheses designates the portion of individuals who participated in a particular activity, averaged over the 3 years (2006, 2009, and 2012)

Figure 2b denotes that in the recession year, people on average spent more time at home for work than in the pre-recession year. Similarly, in the same year, people spent more time doing discretionary activities at home. Aguiar et al. (2013) reported that during the recession (defined from 2008 to 2010 in their study) people spent more time in leisure at home in the form of watching TV and sleeping. We also observed that the tendency of spending more time at home for doing work and discretionary activities remained unchanged in the post-recession year. On the other hand, some activity durations did not change during the recession, but changes happened only after the recession. For example, average work travel time increased in 2012 (see Fig. 2c).

Figure 2d depicts a decrease in the average duration of non-work activities performed during work hours over the three data points. We found that for non-work activity during work hours, people mostly take meals (lunch) outside the workplace. Since there were more part-time workers during the recession (Borbely 2009), they might participate less in any non-work activities during work hours, for example taking meals outside the workplace (49% of people did so during the recession compared to 57% in the pre-recession year). Less participation in non-work activities during work hours in the recession year (cf. Table 1) might reduce the average duration of these activities in that year than in the pre-recession year. Interestingly, even in the post-recession year, a lower percentage of people did non-work activities during work hours

than the pre- and during recession years and this reduced participation might cause the average duration to reduce even more. The changes shown in Fig. 2a, b appeared more prevalent than the other two categories in terms of the average portion of individuals participating in various activity types over the three years.

Model specification

To identify the nature of changes in tour choice during the recession, a causal structure was conceptualized between activity-travel participation and the choice of tours. This structure also captured the effects of socio-demographic and economic factors on activity-travel as well as tour choice indicators. More specifically, we used multiple group structural equation modeling (SEM) to investigate invariance in causal structure across the pre (2006), during (2009) and post (2012) recession years.

Structural equation modeling (SEM) is a comprehensive methodological framework that can simultaneously estimate the causal relationships among a set of observed variables based on a specified model (Kaplan 2008). The strength of an SEM is that, in addition to identifying the direct effect of one variable on another, it can capture the indirect effect as well through other mediating variables. The summation of direct and indirect effects represents the total effect that provides valuable insights on the interrelationships between variables. The conceptual structure of an SEM can be graphically depicted by path diagrams. An arrow in a diagram indicates the direct effect from one variable to another. The rectangular boxes represent exogenous and endogenous variables. A variable is exogenous if it is not determined by the model (an arrow is directed from it) and it is endogenous if it is determined by the model (an arrow is directed to and/or from it).

Structural equation modeling (SEM) has been widely used in travel behavior research, including trip chain generation (Golob 2000), spatial features and car availability (Van Acker et al. 2014), and commuter activity-travel patterns (Kuppam and Pendyala 2001). Multiple group SEM has also been used in previous studies to identify differences across gender in terms of internet use (Ren and Kwan 2009), activity-travel participation (Susilo et al. 2019), and public transit usage (Fu and Juan 2017); to identify differences in attitudes toward public transit between car and non-car owners (Thøgersen 2006) and differences in commuting behavior between work only and more complex tours (Van Acker and Witlox 2011); and also to compare mode-specific preference groups (Fu and Juan 2016), sectors of the trucking industry (Golob and Regan 2001), and two working women groups (Rafiq and McNally 2018). However, little is known about the use of multiple group SEM to explore the temporal differences in the proposed causal structure. The model specifications and conceptualized causal structure are described next.

The exogenous and endogenous variables

The model's endogenous and exogenous variables and their summary statistics are shown in Tables 1 and 2, respectively. The endogenous variables are of three broad types: activity duration, travel duration, and choice of tours. There are a total of seven activity duration variables and six travel durations: one variable is for in-home work activity and the other six are for out-of-home activity (one work and five non-work), each with a corresponding

Table 1 Summary statistics of endogenous variables

Variables	2006			2009			2012		
	% cases >0	For cases >0		% cases >0	For cases >0		% cases >0	For cases >0	
		Mean	SD		Mean	SD		Mean	SD
Tour choice (1 = yes, 0 = no)									
Work-only tour	40.2	457.9	180	40.7	451.7	185.4	41.7	470.7	180.6
Work-nonwork mixed tour	49.4	559.8	190.3	45.6	566.1	183.4	46.8	566.8	182.9
Simple non-work tour	39.3	108.1	94.5	38.1	110.7	105.6	37.8	110.7	97.2
Complex non-work tour	21.1	218.1	138.9	21.3	220.3	146.1	18.8	210.5	149.7
Activity duration (minutes)									
Work at home	25.8	141.7	159.9	29.5	149.0	171.7	28.7	153.7	168.6
Work out-of-home	86.1	444.0	154.9	83.2	438.6	159.1	85.2	445.9	153.2
Non-work way to work	22.1	44.5	83.8	20.9	48.2	91.6	20.3	39.1	66.3
Non-work during work	14.7	39.0	45.0	12.7	37.0	44.7	11.0	36.4	36.1
Non-work way to home	31.8	75.2	95.3	30.6	71.2	94.5	32.6	73.1	89.8
Non-work before work	20.6	135.4	133.7	21.6	133.3	128.4	19.9	126.4	125.1
Non-work after work	37.8	130.3	109.8	36.1	130.7	111.6	34.1	128.4	116.3
Travel duration (minutes)									
Work travel	86.1	49.4	42.1	83.2	51.7	43.6	85.2	55.4	51.0
Non-work travel way to work	22.1	16.2	37.6	20.9	17.0	37.9	20.3	12.1	13.2
Non-work travel during work	14.7	22.7	23.4	12.7	26.6	36.7	11.0	28.4	36.9
Non-work travel way to home	31.8	22.1	24.6	30.6	21.4	35.4	32.6	23.3	34.0
Non-work travel before work	20.6	50.2	46.6	21.6	50.4	53.4	19.9	50.7	58.0
Non-work travel after work	37.8	44.7	46.0	36.1	49.5	60.1	34.1	52.3	75.5

travel duration. Finally, we have four tour choice binary variables indicating whether an individual made at least one tour of a given type. In Table 1, for a given year the first column represents the percentage of respondents that performs a particular tour or activity, and the second and third columns show the average time spent on a particular tour or activity for the participating respondents and the associated standard deviation respectively. All durations are provided in minutes.

Table 2 Summary statistics of exogenous variables

Variables	2006		2009		2012	
	Mean	SD	Mean	SD	Mean	SD
Total respondents	2712		2723		2816	
Household characteristics						
Household size	2.98	1.49	2.93	1.48	2.94	1.52
Household ownership						
Binary: 1=Owned, 0=Rented with or w/o cash	0.78	0.42	0.76	0.43	0.72	0.45
No. of children						
No. of children aged between 0–5	0.24	0.53	0.24	0.55	0.25	0.57
No. of children aged between 6–10	0.26	0.56	0.26	0.57	0.26	0.57
No. of children aged between 11–18	0.36	0.71	0.33	0.67	0.33	0.67
Monthly household income (USD)						
Binary: 1=Low income (less than $20 K)	0.10	0.30	0.09	0.29	0.11	0.31
Binary: 1=Middle income ($20 K to $60 K) (baseline)	0.41	0.49	0.39	0.49	0.38	0.48
Binary: 1=High income ($60 K or more)	0.49	0.50	0.52	0.50	0.52	0.50
Personal characteristics						
Type of employment						
Binary: 1=Full time, 0=Part time	0.81	0.39	0.80	0.40	0.80	0.40
Ethnicity status						
Binary: 1=Hispanic, 0=Others	0.12	0.33	0.14	0.35	0.13	0.34
Multiple job status						
Binary: 1=Yes, 0=No	0.12	0.33	0.14	0.34	0.11	0.31
Gender						
Binary: 1=Male, 0=Female	0.49	0.50	0.49	0.50	0.50	0.50
Age	41.31	12.97	42.52	13.07	43.57	13.23
Marital status						
Binary: 1=Married and spouse employed	0.44	0.50	0.41	0.49	0.40	0.49
Binary: 1=Married and spouse unemployed	0.12	0.33	0.14	0.35	0.14	0.35
Binary: 1=Single (baseline)	0.44	0.50	0.45	0.50	0.45	0.50
Metropolitan status of residential location						
Binary: 1=Principal city (baseline)	0.29	0.45	0.29	0.46	0.31	0.46
Binary: 1=Suburb	0.52	0.50	0.51	0.50	0.50	0.50
Binary: 1=Non-metropolitan area	0.19	0.39	0.20	0.40	0.18	0.39
Seasonal effect						
Binary: 1=Winter, 0=Others	0.26	0.44	0.26	0.44	0.26	0.44

The exogenous variables shown in Table 2 include household and personal socio-demographic characteristics, residential location variables, and seasonal effects. Summary statistics in Table 2 reveal some changes in employment characteristics during the recession. For example, the percentage of full-time workers slightly decreased during the recession from before the recession (81% in 2006 and 80% in 2009) whereas the percentage of multiple job holders increased (12% in 2006 and 14% in 2009).
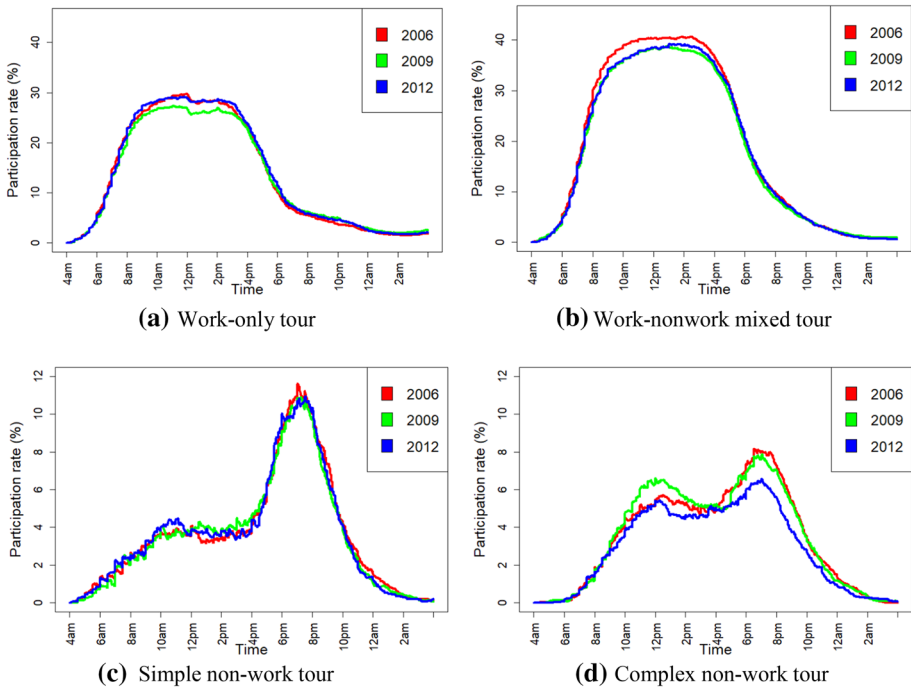
Fig. 3 Participation rates by tour type and time of day

Figure 3 shows the fraction of people making certain types of tours at a particular time of day for the 3 years. It is observed that participation in work-only tours slightly decreased during the recession. On the other hand, the mid-day participation of people in non-work activities by making complex non-work tours increased notably in 2009 compared to 2006 and 2012. However, no significant changes are observed for the other two types of tours.

The structural equation modeling for path model

Denote measured exogenous variables as **X** and measured endogenous variables as **Y**. The equation for the endogenous variables is given by (Kline, 2016):

$$\mathbf{Y} = \mathbf{\Gamma X} + \mathbf{BY} + \zeta \tag{1}$$

where **Y** is an $(m \times 1)$ column vector of endogenous variable and **X** is an $(n \times 1)$ column vector of measured exogenous variables.

The structural parameters are the elements of the matrices are (Golob and McNally 1997):

Γ $(m \times n)$ matrix of direct causal (regression) effects from the (n) exogenous variables to the (m) endogenous variables;

B $(m \times m)$ matrix of causal links between the m endogenous variables; and

ζ $(m \times 1)$ matrix of m error terms.

Equation (1) can be expressed in matrix form as (Kline 2016):

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \cdots \\ Y_m \end{bmatrix} = \begin{bmatrix} \gamma_{11} & \cdots & \gamma_{1n} \\ \cdots & \cdots & \cdots \\ \gamma_{m1} & \cdots & \gamma_{mn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \cdots \\ X_n \end{bmatrix} + \begin{bmatrix} 0 & \cdots & \beta_{1m} \\ \cdots & \cdots & \cdots \\ \beta_{m1} & \cdots & 0 \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ \cdots \\ Y_m \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \cdots \\ \zeta_m \end{bmatrix} \tag{2}$$

Other parameter matrices include the covariance matrix of the measured exogenous variables $\boldsymbol{\Phi}$ and the covariance matrix of the error terms $\boldsymbol{\Psi}$, shown in Eq. (3).

$$\boldsymbol{\Phi} = \begin{bmatrix} \phi_{11} & & & \\ \phi_{21} & \phi_{22} & & \\ \vdots & \vdots & \ddots & \\ \phi_{n1} & \phi_{n2} & \cdots & \phi_{nn} \end{bmatrix} \quad \boldsymbol{\Psi} = \begin{bmatrix} \psi_{11} & & & \\ \psi_{21} & \psi_{22} & & \\ \vdots & \vdots & \ddots & \\ \psi_{m1} & \psi_{m2} & \cdots & \psi_{mm} \end{bmatrix} \tag{3}$$

For identification of system (1), $\mathbf{B}$ must be chosen such that $(\mathbf{I\text{-}B})$ remains non-singular, where $\mathbf{I}$ is an identity matrix of dimension m. For an identified system, the model implied total effects of the endogenous variables on each other are given by (Golob and McNally 1997):

$$T_{yy} = (I - B)^{-1} - I \tag{4}$$

The total effects of the exogenous variables on the endogenous variables implied by the system are given by (Golob and McNally 1997):

$$T_{xy} = (I - B)^{-1}\Gamma \tag{5}$$

The model parameters of the system in the Eq. (1) are estimated using variance analysis methods, also known as *methods of moments*. The theory is that the population covariance matrix of the observed variables (Σ) can be expressed as a function of a set of parameters θ, shown in Eq. (6) (Lu and Pas 1999).

$$\Sigma = \Sigma(\boldsymbol{\theta}) \tag{6}$$

here θ represents the model parameters of $\boldsymbol{\Gamma}$, $\mathbf{B}$, $\boldsymbol{\Phi}$, and $\boldsymbol{\Psi}$. These unknown parameters are estimated such that the difference between the sample covariance matrix S and the model implied covariance matrix $\Sigma(\theta)$ is minimized. This is achieved by minimizing a fitting function, which is a function of S and $\Sigma(\theta)$. Several estimation methods are available to identify the best fitting model. The maximum likelihood method works well when the endogenous variables have a multivariate normal distribution. On the contrary, the weighted least square mean and variance adjusted estimator accounts for non-normally distributed data (Muthen and Kaplan 1992).

The initial conceptual model

The conceptual tour choice model has the following features: (1) the model captures non-work activity-travel demand and its associated tour choice for workers at different times aligned with the work tour; (2) it distinguishes the degree of variation in non-work activity demand and associated time use with respect to work, and consequently how this variation impacts non-work tour choices between people who work at home and who work out of home; (3) the model explicitly factors in the effect of travel time in addition to activity

duration on tour choices. The last feature stands out as a contrast to earlier models (e.g., Golob 2000), where tour generation was shown to be dependent on activity duration and travel times are hypothesized as the outcome of tour choice. Although activity demand (work or non-work) necessitates the occurrence of a tour, the type of tour undertaken should depend on *both* activity and travel duration. The impact of travel time can be very explicit, as when people use mapping services to find an estimated travel time for a certain activity, and this travel time may influence the decision to chain other activities along the way.

The initial conceptual structure of the proposed model is shown in *solid lines* and an additional link to improve the model is shown in *dashed line* in Fig. 4. The upper figure shows the higher level of the conceptual model, where the demand for activity creates the demand for associated travel and both the activity and travel influence on tour generation. The rectangular boxes in the lower figure represent the endogenous variables and the arrows represent postulated non-zero direct effects and their expected sign. In the following, we discuss the expected interaction between three layers of endogenous variables: activity durations, travel time, and tour choice.

Work and non-work activity interactions

Work is a mandatory activity and usually the least flexible because it is most often pursued at a fixed location on a fixed schedule. Other non-work activities need to be aligned with the work time (Golob and McNally 1997; Rafiq and McNally 2018). Therefore, out-of-home work duration has the following postulated effects: (1) *negative* effects on in-home work duration, (2) *positive* on within work tour non-work activities, and (3) *negative* on before and after work non-work.

The *negative* effects on after work non-work imply that employed persons spending more time working out-of-home might not be interested in going out again after returning
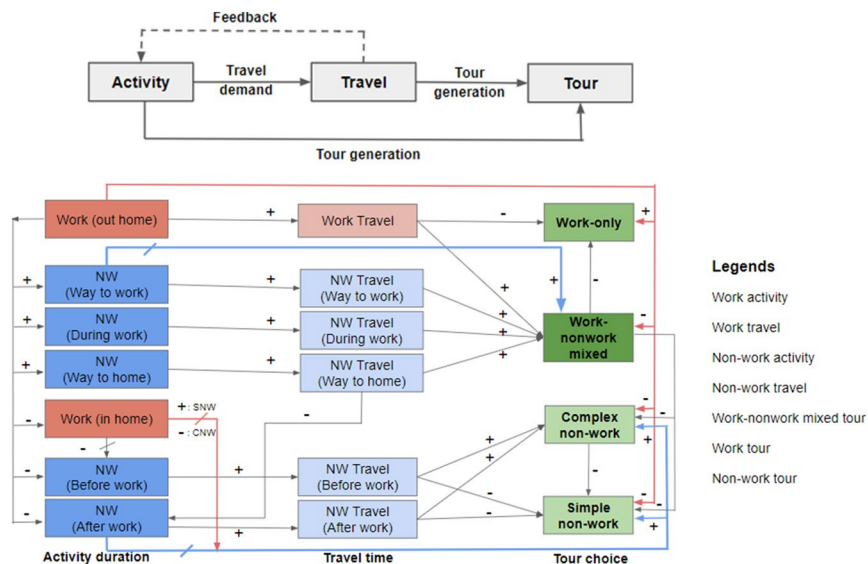

Fig. 4 Structural equation model

from work. They may also have less time to accommodate out-of-home non-work activities before going to work because of less flexibility of work start times. Employed persons may instead prefer to do the same on the way to work that would save them return trips to home. Similar effects can be observed with respect to choosing whether to finish some of the non-work activities on the way to home while returning from work (as part of work tours) or to make a separate "after work" non-work tour. The effects from out-of-home work to 'within work' non-work activities are postulated *positive* because they are part of work tours and are performed when the out-of-home work activities are made.

Similar to out-of-home work, in-home work duration is expected to have negative effects on both "before work" and "after work" non-work. As discussed earlier, since work is a mandatory task, spending more time in work activity naturally reduces the time for other activities since the total duration of a day (24 h) is fixed (Golob and McNally 1997).

Activity and travel interactions

In the model, a direct connection is assigned from each of the out-of-home activities to their associated travel. These direct connections represent travel as a derived demand meaning that the demand for travel is created to participate in out-of-home activities (McNally and Rindt 2007). We expect each of the coefficients to be *positive*. We have added one feedback effect from 'way to home travel time to 'after work' nonwork activity time and expect a *negative* effect.

Activity-travel interactions with tours

In terms of activity and tour choice interactions, activity durations have generally *positive* effects on associated tour choices because activity demand creates the necessities of tours. One exception is out-of-home work duration negatively affecting work-nonwork mixed tour and non-work tours assuming that one spending more time in work may not have enough time left for mixing non-work activities within work tour or making separate non-work tours (simple or complex) before or after the work. Unlike work out-of-home, a positive effect is postulated from work in-home to simple non-work tour anticipating that working at home is more flexible than working out-of-home (Alexander et al. 2010), which will provide more opportunities to make simple non-work tours before or after work.

Causal connections from work travel time to both the work-only and work-nonwork mixed tour choices are provided where we posit the first connection as *negative* and the second one as *positive* assuming that if a person travels a longer distance (longer travel time) for work, it will provide him exposure to a greater range of non-work activity locations, which might increase the likelihood of doing non-work activities during the journey to or from work (Kondo and Kitamura 1987; Nishii et al. 1988; Bhat 1999). All non-work travel within work tours are expected to have *positive* coefficients to work-nonwork mixed tours anticipating that the tendency to combine non-work with work increases with the increase of distance between home and non-work activity locations (Kondo and Kitamura 1987). Moreover, two direct connections from each of the non-work travel times (before and after work) are assigned to simple and complex non-work tours. The anticipated connections with simple non-work tour are *negative* and with complex non-work tour as *positive*. It is assumed that if a person has to travel longer distances (longer travel time) to avail a non-work activity before or after work activity, he might be more interested to chain other non-work activity demands within that tour by making a complex tour. In contrast, if

the travel distance to access a non-work activity is short, that person might be more interested to make frequent simple non-work tours.

Interactions between tours

It is postulated that chaining more than one activity within a tour reduces de facto the demand for single purpose simple tours (Golob 2000). Thus, direct links are provided from work-nonwork mixed tour to work-only tour and complex non-work tour to simple non-work tour assuming each coefficient to be *negative*. Moreover, a work-nonwork mixed tour is anticipated to affect the choice of non-work tours *negatively*.

Effects of exogenous variables and error-term covariance

For each of the specified endogenous variables, a subset of exogenous variables is selected that may potentially affect the endogenous variable. In the model, we have added error-term covariances between two similar sets of variables, for example, work only and work-nonwork mixed tours, simple and complex non-work tours, and non-work before work and after work. Also, two error-term covariances are added: between work travel to way to work and way to home non-work activity. This is because these non-work activities are part of a work tour of an individual when the individual is traveling to or from work and the unaccounted factors affecting the work travel may be correlated with the duration of those non-work activities performed on the way.

Degree of causal invariance due to recession

Given the postulated conceptual model, we are interested in investigating how this causal structure varies in terms of size, sign, and significance of the model parameters across pre (2006), during (2009), and post (2012) recession. We anticipate that the model parameters will vary significantly across the 3 years.

Estimation of the model

Based on our conceptual structure of endogenous variables and the best possible combination of exogenous variables, we estimated two *multiple group structural model* (constrained and unconstrained) using the `lavaan` package in R. We took logarithms of all activity and travel durations to reduce skewness (however, some skewness in travel durations still remained). We used WLSMV (weighted least square mean and variance adjusted) estimator that works with categorical endogenous variables (we had four binary variables for tour choices, which were regressed by a probit function in `lavaan` (R documentation 2018)) and that accounted for non-normally distributed data (Muthen and Kaplan 1992).

We specified one model by constraining all the corresponding parameters to be equal for 2006, 2009, and 2012 and another model without having such constraints. The main model fit statistic was a χ^2 statistic that tested whether the observed covariance matrix and the model implied covariance matrix were equal. Smaller χ^2 value with high *p-value* (*p-value* > 0.05) indicates better model fit. However, χ^2 value tends to increase with sample size so models with larger sample sizes might show larger χ^2 value and subsequently may lead to rejection of an otherwise good model (Van Acker and Witlox 2011). We report

other model fit indices, such as Root Mean Square Error Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker Lewis Index (TLI).

Our conceptual structure resulted in large χ^2 value with a lower *p-value* for both constrained and unconstrained models, which indicates a poor fit. To improve the model, we introduced a direct effect from work only tours to work-nonwork mixed tours and found that this additional direct connection (shown in *dashed line* in Fig. 4) improved the model significantly: $\chi^2 (751) = 1187$ (*p-value* = 0.000) for the constrained model and $\chi^2 (393) = 742$ (*p-value* = 0.000) for the unconstrained model. This indicated that these two tour choices demonstrate feedback effects. In other words, the choice of work-only tour affected the choice of work-nonwork mixed tour and vice versa. Other model fit indices indicate satisfactory fit (constrained: χ^2 /df = 1.58, RMSEA = 0.015, CFI = 0.993, TLI = 0.996; unconstrained: χ^2 /df = 1.88, RMSEA = 0.018, CFI = 0.995, TLI = 0.994) (Van Acker et al. 2014). We subsequently performed a χ^2 difference test between the constrained and unconstrained models ($\chi^2 = 445$, df = 358, $p = 0.001 < 0.05$), which confirms that model parameters are *not* equal across pre-, during, and post-recession years. Therefore, we choose the unconstrained version as our final model.

Model results and discussion

Here we discuss unstandardized coefficients of *direct* effects (Table 3, c.f. Appendix) and *total* effects (Table 4, c.f. Appendix) that are statistically significant. If not otherwise stated, all the mentioned effects below represent direct effects. Note that exogenous variables are not influenced by any other model variable, whereas endogenous variables are both influenced (either directly or indirectly) and can influence other variables. In both tables, the set of exogenous and endogenous variables are provided in rows and the list of endogenous variables are in columns so that for a pair of variables corresponding effects (direct or total) can be interpreted in the direction from rows to columns. Again, each cell represents three coefficients for a pair of variables in 2006, 2009, and 2012, respectively. Three dashes indicate that the particular variable is a part of the model, but not significant whereas blank cells indicate that the particular variable was not part of the model.

Effects between endogenous variables

Work and non-work activity interactions

Work out-of-home positively affected non-work activities performed within work tours and negatively affected "before work" and "after work" non-work activities. Non-work activities performed on the way to home had higher effects than during work and way to work. This indicates that if people need to perform non-work activities as a part of their work tours, they tend to prefer performing them more on the way to home than the other two ways. A rationale for this behavior may be that the post-work way-to-home period places fewer constraints on performing non-work activities, whereas the way-to-work and during work timeslots are more constrained by the fixed nature and importance of the work activity. Similar findings were reported in previous works (Strathman et al. 1994; Castro et al. 2011). Moreover, way to home non-work has negative total effects (cf. Table 4) on "after work" out-of-home non-work activities, which suggests that when people meet their non-work activity demand on their way to home, they may be reluctant to make another

tour after returning home (similar results appear in Bhat and Singh (2000)). As anticipated, both out-of-home work and in-home work affected before and after work non-work activities negatively.

Activity-travel interactions

All estimated activity-travel coefficients were found positive and statistically significant. We found one feedback effect from way-to-home travel time to "after work" non-work activities (negative). This implies that people who spent more time traveling on their way to home have less time available for out-of-home, non-work activities after returning home (also reported in Golob 2000; Kitamura et al. 1996).

Activity-travel interactions with tours

The model results based on *total* effects reveal that out-of-home work *positively* affected the choice of work tours, higher on work-nonwork mixed tours than work-only tours. This result contradicts our assumption and the study results reported in Bhat (1999). However, results from the direct effect show our expected *negative* correlation between out-of-home work duration and the choice of work-nonwork mixed tour. Secondly, work time *negatively* affected the choice of non-work tours (as postulated). Moreover, the choice of work tour type depended on work travel time. For instance, we found that work-only tours were preferred when work travel time is longer but this differs from our postulated association between these two variables. However, this positive correlation can be rationalized by the time constraints and stress people may face when performing additional non-work activities in a work tour while traveling longer distances (times) for work.

Both "before work" and "after work" non-work activities had positive effects, as expected, on choosing simple non-work tours, and "after work" had the higher influence (coefficients are 0.284 and 0.316 respectively in 2006, Table 4). Effects on complex non-work tours were also positive albeit smaller sizes and they are obtained only from total effects. This observation matches with summary statistics in Table 2: in 2006, 38.8% of people were reported to make simple non-work tours compared to 21.3% of people making complex ones, and about 21% of people making non-work tours before work versus about 38% after work. Furthermore, both before work and after work non-work travel time affects non-work tour choice as postulated but not all effects are obtained with significance for all years (cf. Table 4).

Interactions between tours

Our model results show that, as expected, work-nonwork mixed tours reduced the demand for work-only tours. Moreover, making work-nonwork mixed tours negatively affected the choice of both simple and complex non-work tours.

Effects of exogenous variables

Women tended to perform more out-of-home non-work activities (specifically "way-to-work" and "way-to-home" non-work) and consequently made more work-nonwork mixed tours than men (cf. Table 4). Similar observations were found in prior work (Strathman et al. 1994; Bhat 1999; Kuppam and Pendyala 2001). Men usually traveled

farther to work as they have longer work travel time and make less complex non-work tours than women. Older people did more in-home work, less out-of-home work, and less "after work" non-work compared to younger people (Bhat and Singh 2000; Rajago-palan et al. 2009). They usually did not mix work with non-work and thus made fewer complex tours (total effects) (Kuppam and Pendyala 2001).

Generally, single persons tended to do more non-work activities than their married counterparts, in part because they may have more flexible time management. Married persons with unemployed spouse spent less time in non-work activities than those with an employed spouse (while all effects are negative, the effects for the former group had mostly smaller absolute values). This indicated that unemployed spouses might take care of some household tasks while their partners were at work and allow them to do less non-work. Persons with children usually performed more mixed tour and less work-only tours (total effects). Persons having children aged below 5 did less "after work" non-work activities, whereas persons with children aged 6–18 did more "after work" (mostly perhaps via simple non-work tours) as these children may perform more non-home activities (Bhat and Singh 2000).

Full-time workers spent less time in non-work activities (and consequently fewer non-work tours) than part-time workers, except for during work when they spent more, possibly to leave their workplace to have lunch during midday (Castro et al. 2011). People with multiple jobs tended to spend less time working out-of-home than people with a single job. They preferred to do non-work before their work and when they combine their non-work with their work, they did so particularly on their way to home (cf. Tables 3 and 4) (Castro et al. 2011). One notable observation is that people with multiple jobs tended to choose work only tours differently in the pre- and during recession years (negative total effect in 2006, but positive in 2009, a detailed discussion is provided in a later section). High-income people made more non-work tours and fewer work-only tours (Strathman et al. 1994; Kuppam and Pendyala 2001). People living in suburbs and non-metropolitan areas did more out-of-home work and less non-work of any type than those living in principal cities. Figure 5 summarizes how the tour choices vary for a set of ten socio-demographic characteristics.
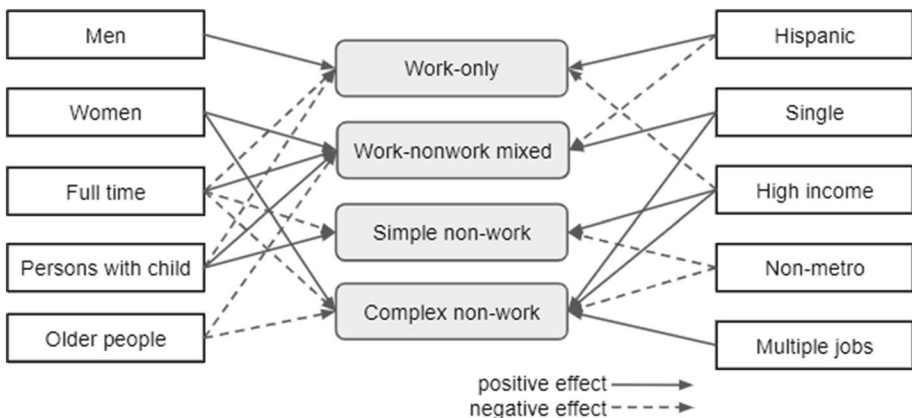

Fig. 5 Significant effects of socio-demographic variables on tour choices

Differences in causal effects in pre-, during, and post- recession years

The significant causal effects (i.e., model coefficients) identified for the recession are now compared to these effects for the pre- and post-recession years. To measure the statistical difference between two coefficients observed at two different years (which are assumed to be independent since ATUS does not represent panel data), we apply a Z-test; in particular, for two coefficients, say β_1 and β_2 with standard errors, se_1 and se_2, the test statistic is: $Z = (\beta_1 - \beta_2)/\sqrt{se_1^2 + se_2^2}$, which is supposed to follow standard normal distribution under the null hypothesis that both coefficients are equal (Kühne et al. 2018).

In regard to highlighting the differences in causal effects, we identify three categories of effects (direct and total) that are discussed below. Since the list of variables under each category is broad, we limit discussion mostly to those variables that affect tour choices.

(a) *Effects that are significant in 2009 but neither in 2006 nor in 2012 (unique recession effects)*

We observed that during the recession the tendency of choosing complex non-work tours was low for full-time workers and aged people. Interestingly, the winter season played a significant role during the recession in choosing simple tours. More specifically, people less preferred to make work-only tours or simple non-work tours in winter compared to other seasons.

(b) *Effects that are significant in 2009 and in either 2006 or 2012, with 2009's effects significantly differ from the other year's effects (whichever exists)*

People with multiple jobs showed a sheer variation in their work tour choices. For instance, work-only tours were less preferable pre-recession (negative total effect), whereas the contrary was true during the recession (positive total effect). In the pre- and post-recession years, people preferred to make work-nonwork mixed tours more than work-only tours. On the other hand, in the recession year, they preferred to make work-only tours more, either by making one long work-only tour (from one work to another without returning home) or making more work-only tours (returned home before going to another job).

We have checked this categorically in our dataset and noted that the fraction of people with multiple jobs making work-only tours in the recession year was indeed higher than the pre- and post-recession years (44% compared to 36% and 38%, respectively). Moreover, during the recession a higher fraction of people doing multiple jobs performed *work-only tours* in combination with work-nonwork mixed tours or other non-work tours than pre- and post-recession years (8% people combined work-nonwork mixed tours compared to 4% and 5% respectively whereas 25% of people combined any non-work tours compared to 18% and 17%, respectively). One possible reason for such behavior may be less out-of-home work during the recession (average out-of-home work duration in 2009 was around 366 min which differ significantly from 383 and 378 min in 2006 and 2012 respectively with p-values < 0.05) led to make other work or non-work tours with work-only tours.

(c) *Effects that are significant in all the 3 years and represent one of the following four sub-trend groups:*

Group 1 considers norms that did not change in pre-, during, and post-recession years. These are effects that remained unchanged and constitute the time-invariant travel behavior of the target population. Here, about 47% were effects that did not change in the pre-,

during, and post-recession years. For example, the structural relationships of out-of-home work activity with different non-work activities and the choice of tours did not change in the three target years. That means the process of balancing less mandatory tasks (non-work) and choosing associated work or non-work tours based on the mandatory task (work) remained unchanged over time.

Group 2 represents 2006 norms that changed during the 2009 recession but returned to the 'old norm' in 2012. This group reflects about 9% of the identified effects. For example, part-time workers were more likely to make simple non-work tours than full-time workers since they had to spend less time at work and thus, had more chances to make non-work activities by making separate non-work tours. This effect was reduced in the recession year compared to the pre- and post-recession years. One possible explanation may be that during the recession, part-time workers might have replaced some of their out-of-home non-work demands with an equivalent in-home counterpart, say shopping online from home instead of going to marketplaces or by performing recreational activities at home instead of elsewhere. Data showed that average in-home non-work activity duration was indeed increased significantly during the recession compared to pre- and post-recession (836 min compared to 824 and 826 min, respectively). Also, a lower fraction of part-time workers preferred to make simple non-work tours in 2009 than 2006 and 2012 (39% compared to 45% and 43%, respectively).

As anticipated, work-nonwork mixed tour reduced the demand of making complex non-work tours in all the 3 years. This negative effect was higher in the recession year than the pre- and post-recession years. This indicates that during the recession, workers who made non-work stops within their work tours may have preferred to meet their non-work activity demands within that tour to avoid extra home-based trips associated with separate complex non-work tours.

Group 3 contains 2006 norms that changed during the 2009 recession and were maintained in 2012 as 'new norm' (9% of total identified effects). We found positive associations between "before work" non-work activity time and the choice of simple non-work tour in all the 3 years. The positive association between these two variables indicates that since there are time constraints before starting a work activity, an individual may prefer to meet the demand for a non-work activity that arises at that time—for example, dropping children at school—by making a simple non-work tour instead of a complex one.

It is also observed that the recession year had a larger effect than the pre-recession year and this larger effect continued during the post-recession year. The larger effect might be due to the higher percentage of people participating in non-work activity before starting their work in 2009 than in 2006 (22% people did so in 2009 compared to 21% in 2006, cf. Table 1). This higher participation rate perhaps increased the chances of making a simple non-work tour in the recession year. During the recession as individuals spent significantly more time working at home (mean around 37 and 44 min for 2006 and 2009 respectively with *p-value* = 0.005), it perhaps provided some flexibility in terms of when to start and finish the work and thus, led them to participate in non-work activities before starting the work (Alexander et al. 2010) more than in the pre-recession year. Interestingly, this recession effect did not change in the post-recession year. Data reveals that during a recession a higher fraction of people, who had non-work activity before starting work, worked only from home compared to the post-recession year (45% did so during the recession compared to 43% in the post-recession year). It also shows that the new trend of performing single or multiple jobs both at home and workplace remained unchanged (8% people in 2006 compared to 10% in both 2009 and 2012) and the average time spent on work at home did not significantly differ between 2009 and 2012. These facts may rationalize having some

degree of flexibility in the post-recession year to make non-work activities before starting work by making simple non-work tours.

Group 4 constitutes 2006 norms that did not change during the 2009 recession but changed after the recession. It contains 5% of the effects. Two notable such effects are, first, while making work tours, men were more likely to make work-only tours and less likely to work-nonwork mixed tours and, second, the size of these effects were larger in the post-recession year compared to the recession year. Since women were reported to spend less time in out-of-home work than men (430 min versus 447 min in 2009 where the difference is significant with *p-value* = 0.000) and they happen to take care of their children and household chores more often (Rosenbloom 2006), they manage to do more non-work activities within work tours than men (for example, drop off children at school or daycare on the way to work or consumer purchases for the household on the way to home from work). This tendency was higher in the post-recession year because the work out-of-home time gap between women and men was also higher in that year (429 versus 459 min with *p-value* = 0.000).

The percentages of causal effects for each of the *groups* are depicted in Fig. 6. For each of the 3 years (2006, 2009, and 2012) the overlapping regions designate the degree to which the associated two (or three) years' activity-travel causal relationships show no statistically significant differences. For example, Group 4 indicates that 5% of casual effects did not show a significant difference between 2006 and 2009 only whereas Group 1 shows that 47% of the effects did not show any differences across any year pairs.

Conclusions

A recession can bring a wide spectrum of potential changes to peoples' lives. The recent 2007–09 recession had significant changes in employment including higher unemployment rates, reduction in workers' hours, more work activity at home, and an increasing number of part-time workers and multiple job holders. Changes also occurred in time allocation and activity-travel behavior. This study investigated how the changes in time allocation in
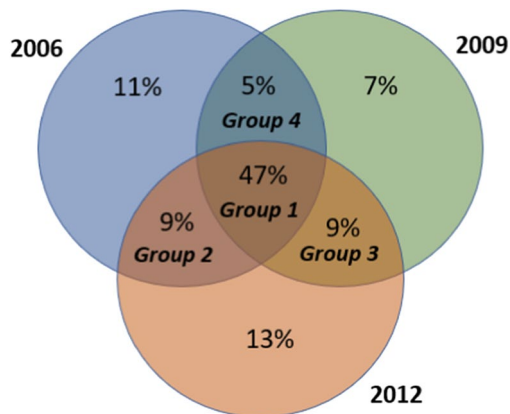
(percentages are rounded to the nearest whole numbers and may not add to 100 percent)

Fig. 6 Activity-travel causal effects for pre-, during-, and post-recession years

various work and non-work activities, as well as in the nature of jobs, affect an individual's daily choice of tours during the 2009 recession. Unlike previous studies, this study captured the nature of changes in travel behavior during the recession by using a rigorous methodological framework. We applied multiple group structural equation modeling (SEM) by conceptualizing a causal structure between activity-travel participation and choice of tours. This structure also captured the effects of socio-demographic and economic characteristics on activity-travel as well as tour choice indicators. We used the American Time Use Survey (ATUS) data, the most reliable national-level cross-sectional survey data providing an individual's time usage in various activities on a single day. The multiple group SEM enabled assessment of the invariance in causal structure across the pre (2006), during (2009) and post (2012) recession years.

Results show there were measurable differences in activity-travel relationships and their role in tour choice in the recession year compared to pre- and post-recession years. While analyzing the temporal changes in causal effects, we identified four sub-trend *groups*. We observed that 47% of effects did not change in the pre-, during, and post-recession years (Group 1). For instance, the process of balancing non-mandatory tasks (non-work) and choosing associated work or non-work tours based on the mandatory task (work) remained unchanged over time. About 9% effects of 2006 changed significantly during the 2009 recession but returned to the 'old norm' in 2012 (Group 2). While part-time workers are more likely to make simple non-work tours than full-time workers, the effect became significantly lower in the recession year than the pre- and post-recession years. Moreover, during the recession workers preferred more to meet non-work activity demands within the work tour instead of making separate complex non-work tours. A number of effects in 2006 (about 9%) changed significantly during 2009 and maintained into 2012 as a 'new norm' (Group 3). For example, the tendency of making simple non-work activities before work increased during the recession and continued in the post-recession year. Last, 5% of the effects in 2006 did not change during the 2009 recession but did change after the recession (Group 4). For example, men were more likely to make work-only tours and less likely to work-nonwork mixed tours and the size of these effects was larger in the post-recession year compared to the pre- and during recession years.

Results from this study suggest how the changes in time usage and in the nature of jobs affect the tour choices of an individual. For instance, prior to the recession, people having multiple jobs made fewer work-only tours; during the recession, the contrary was true. Our findings provide valuable insights on possible changes in worker's tour choice during an economic downturn by identifying factors or effects that are *sensitive due to recession*, which would contribute to building better pattern choice sets in tour-based models for a recession year. Moreover, the terms that we have introduced to analyze the recession effects such as old norms and new norms can have broader applications to other studies related to *trend analysis*.

Since the purpose of developing the multiple group SEM structure was to identify the temporal variation in the causal structure among socio-economic characteristics, activity-travel participation, and choice of tours, it cannot be immediately used for long term travel demand forecasting purpose. Nonetheless, the conceptual SEM structure will provide valuable insights on how workers allocate time to various out-of-home activity demands at different times of a day aligned with work activity, how these activity demands are allocated to different tours, how travel time affects activity time (feedback effect), and what kind of tours are preferred by an individual with given socio-economic characteristics, and

consequently, contribute to better development of a *tour choice prediction model* based on the most reliable year-wise national-level time-use survey data. The methodology that we used to identify changes in causal effects between activity-travel and tour choice over three different years can also be applied to identify changes in travel behavior due to other short-term or long-term *external changes* in society over time, such as automation, gig economy, and disease outbreak.

This study has some limitations. Since ATUS data do not provide spatial data and household vehicle ownership data, it was not possible to capture these effects on tour choice. It would be interesting to investigate tour behavior by using panel data for those individuals who had a job in the pre-recession year, lost their job during the recession, and again obtained a job in the post-recession year. This study focused only on employed individuals, reserving the analysis of changes in tour choice for unemployed people for future work. Understanding post-recession effects over time by using 2009, 2012, and 2015 ATUS data is also left for future research.

Author contributions The authors confirm contribution to the paper as follows: RR, MGM: study conception and design; RR, MGM: analysis and interpretation of results; RR, MGM: draft manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix

See Tables 3 and 4.

Table 3 Direct effects of exogenous and endogenous variables (see footnotes for explanation)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
HH size	–	–0.029**	–0.094*	–	–	–	–	–
	–	–	–0.100*	–	–0.103*	–	–	–
HH ownership	–	–	–0.076*	–	–0.110*	–	–0.050**	–
	–	–0.141**	–	–	–	–0.169**	–0.126*	–
No. of child aged 0–5	–	0.112*	–	–	0.155*	–	0.191*	–
	–	–	–	0.109*	0.128**	–0.176**	0.194*	0.083**
No. of child aged 6–10	–	–	–	–	0.094**	–0.171*	–	–
	0.046**	0.110*	0.097**	–	–	–0.274*	0.105*	–
No. of child aged 11–18	–	0.078**	0.093**	–	0.100**	–	–	–
	–	0.154*	–	–	–	–	–	–
Low income (<$20 K)	–	–	–	–	–	0.319**	0.131*	–
High income (> = $60 K)	–	–	0.173*	0.106*	0.301*	–0.452*	–	0.210*
	–	–	–	–	0.339*	–0.443*	–	0.127*
	–	–	–	0.097**	0.348*	–0.389*	–	0.204*
Employment type	–0.151*	–	0.156**	–	–	0.708*	–0.257*	–

Table 3 (continued)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
	– 0.145*	–	0.226*	– 0.116*	0.159*	0.624*	–	0.169*
	– 0.177*	–	0.218*	–	0.280*	0.643*	– 0.139*	–
Ethnicity	–	–	– 0.444*	– 0.169*	– 0.385*			
	0.174*	–	– 0.267*	– 0.174*	– 0.448*			
	0.159*	–	– 0.439*	–	– 0.457*			
Multiple jobs status	0.094*	–	–	–	0.531*	– 0.463*	–	–
	0.190*	–	– 0.296*	–	0.421*	– 0.232**	0.150*	–
	0.128*	–	– 0.331*	–	0.423*	– 0.492*	0.203*	0.140*
Gender				– 0.088**	0.100**	–	–	0.149*
				– 0.124*	0.168*	–	– 0.135*	–
				– 0.085**	–	–	– 0.236*	–
Age	–	–	–	0.011*		– 0.010*	–	–
	–	–	–	– 0.003**	0.009*	– 0.007**	–	–
	–	–	–	–	0.010*	– 0.008*	–	–
Married & spouse employed	–	–	–	–	0.183*	–	–	–
	–	–	–	–	–	– 0.262*	–	–
	–	–	0.128**	–	–	– 0.261*	–	– 0.107**
Married & spouse unemployed	–	–	–	–	–	–	– 0.241*	–
	–	–	–	– 0.142**	0.348*	–	– 0.156**	–
	–	–	–	–	–	– 0.377*	–	–
Suburb	–	–	–	–	–	0.225*	–	–
	– 0.055*	–	–	–	–	–	–	–

Table 3 (continued)

From — Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
Non-metropolitan area	0.073** 0.083**	– 0.155*	–	–	– 0.159** – 0.253*	0.270* 0.350* 0.473*	– 0.118*	– 0.165*
Winter	– 0.059*	–	–	–	–	–	–	–
Work-only tour	–	–	0.199* 1.059* 0.943* 0.914*	–	–	–	–	–
Simple non-work tour								
Work-nonwork mix tour	– 1.062* – 1.091* – 1.073*	– 0.110*		– 0.113* – 0.163* – 0.103*				
Complex non-work tour								
Work in home	–	0.043* 0.044*		– 0.024** – 0.022** – 0.031*				
Work out of home	0.363* 0.285*	0.116*	– 0.297* – 0.130***	– 0.058* – 0.050*	– 0.605* – 0.622*		0.114* 0.124*	0.135* 0.107*

Table 3 (continued)

From	Variables	To							
		Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
	NW way to work	0.308*	0.109*	− 0.187*	− 0.054*	− 0.587*		0.104*	0.093*
				0.615*					
				0.552*					
				0.707*					
	NW during work			0.959*					
				0.758*					
				0.597*					
	NW way to home			0.603*					
				0.640*					
				0.583*					
	NW before work		0.576*		0.151**				
			0.429**		0.188*				
			0.922*		–				
	NW after work		0.673*		–				
			–		–				
			0.719*		0.131**				
	Work travel	0.174*		–					
		0.309*		− 0.251*					
		0.271*		–					
	NW travel way to work			0.488*					
				0.325*					
				0.213**					

Table 3 (continued)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
NW travel during work		–	0.364*	–				
NW travel way to home		–	0.396*	–				
NW travel before work		–0.775**	0.251*	0.368*				
NW travel after work		–0.513**		0.236*				

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
HH size	–0.132*	–	–		–	–	–	–	–
	–0.065**	–	–0.120*		–	–	–	–	–
	–0.118*	–	–0.129*		–	–	–	–	–
HH ownership	–0.208*	–	–		–	–	–	–	–
	–	–	–		–	–	–	–	–
	0.179**	–	–		–	–	–	–	–

Table 3 (continued)

From	Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
	No. of child aged 0–5	0.246*	0.114**	− 0.189**	–	0.061*	–	–	–	–
		0.171*	–	–	–	–	–	0.053**	–	–
		0.172*	–	–	–	0.088*	–	0.074*	–	–
	No. of child aged 6–10	0.279*	–	–	–	–	0.051**	–	–	–
		0.117**	–	0.286*	–	0.082*	–	0.048**	–	–
		0.201*	–	–	–	–	–	–	–	− 0.057**
	No. of child aged 11–18	0.111**	–	0.176*	–	0.038**	–	–	–	–
		0.207*	–	0.210*	–	0.046**	–	–	–	0.045**
		–	–	0.206*	0.070*	–	–	–	–	–
	Low income (<$20 K)	− 0.250**	− 0.315**	–	–	–	–	–	–	–
		− 0.236**	–	− 0.424*	–	–	–	–	–	–
	High income (>= $60 K)	0.234*	–	0.217*	− 0.153*	–	–	–	− 0.050**	–
		0.144**	–	0.348*	0.076**	–	–	–	–	–
		0.162*	–	–	–	–	–	–	–	–
	Employment type	− 0.254*	–	–	–	–	–	0.070**	0.070*	–
		− 0.173*	–	–	–	–	–	0.093*	–	–
		–	− 0.166*	–	–	–	–	–	–	–

Table 3 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
Ethnicity	0.264*	–	–	–	–	–	–	–	–
Multiple jobs status	0.265* 0.221*	− 0.356* − 0.188**	–	0.117* 0.203*	–	–	–	–	–
Gender	− 0.278* − 0.180* − 0.357*	–	–	0.115* 0.086*	− 0.078* − 0.064*	0.103*	−0.072** − 0.081*	–	–
Age	–	–	− 0.011* − 0.013* − 0.011*	–	–	–	–	–	–
Married & spouse employed	-0.201*	− 0.268*	–	–	–	–	–	–	0.095*
Married & spouse unem-ployed	− 0.433*	− 0.236** − 0.352*	–	–	–	–	–	–	0.089**
Suburb	–	–	–	–	–	–	–	–	0.064**

Table 3 (continued)

From	Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
To										
		–	– 0.154*	–	–	–	–	–	–	–
		– 0.187*				–	– 0.055**	–	–	–
	Non-metropolitan area	–	– 0.177**	–	– 0.163*	–	–	–	– 0.062**	–
					– 0.227*					
	Winter	–	0.120**	–	– 0.179*	–	–	–	–	–
	Work-only tour									
	Simple non-work tour									
	Work-nonwork mix tour									
	Complex non-work tour									
	Work in home	–	– 0.101*	– 0.050*						
			– 0.086*							
			– 0.069*							
	Work out of home	0.271*	– 0.537*	– 0.267*	0.630*					
		0.247*	– 0.519*	– 0.317*	0.632*					
		0.283*	– 0.469*	– 0.288*	0.630*					
	NW way to work					0.601*				

Table 3 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
NW during work					0.608*	0.720*			
NW way to home					0.554*	0.756*	0.579*		
NW before work						0.705*	0.584*	0.770*	
NW after work							0.598*	0.757*	0.762*
Work travel								0.779*	0.795*
NW travel way to work			−0.157*						0.783*
NW travel during work			−0.122*						
NW travel way to home			−0.120*						

Table 3 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
NW travel before work									
NW travel after work									

Only significant values are shown in the table for clarity of presentation. Each cell represents three coefficients for a pair of variables in 2006, 2009, and 2012 respectively

* 5% level of significance, **10% level of significance; An empty dash (–) indicates that the variable is part of the model, but not significant; Blank cell indicates variable is not a part of the model

Table 4 Total effects of exogenous and endogenous variables (see footnotes for explanation)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
HH size	0.203*	–	–0.190*	–	–	–	–	
	0.183*	–	–0.106***	–	–0.103*	–	–	
	0.244*	–0.047**	–0.181*	–	–0.110*	–	–0.050**	
HH ownership	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–0.126*	–
No. of child aged 0–5	–0.554*	–	0.462*	–	0.198*	–0.169**	0.172*	
	–0.367*	–	0.176**	–	0.235*	–	–	
	–0.447*	0.091**	0.283*	–	0.231*	–0.176**	0.176*	
No. of child aged 6–10	–0.408*	–	0.424*	–	–	–	–	
	–0.361*	0.158*	0.170**	–	0.198*	–0.171*	–	
	–0.418*	–	0.238*	0.154*	0.185*	–0.274*	–	
No. of child aged 11–18	–0.217*	0.125*	0.302*	–	–	–	–	
	–0.320*	0.137*	0.296*	–	–	–	–	
	–0.239*	0.141*	0.231*	–	–	–	0.124*	
Low income (<$20 K)	–	–	–	–	–0.321**	0.319**	–	
	0.282**	–	–0.286**	–	–	–	–	
High income (>= $60 K)	–0.581*	0.102**	–	0.210*	0.574*	–0.452*	–0.051*	0.149*
	–0.601*	0.215*	–	0.214*	0.615*	–0.443*	–0.055*	–
	–0.394*	0.192*	–	0.200*	0.576*	–0.389*	–0.040*	0.168*
Employment type	0.235**	–0.306*	–	–	–0.316*	0.708*	–0.177*	0.168*

Table 4 (continued)

| Variables | From | | | | | | | |
| | To | | | | | | | |
	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
	–	– 0.132*	0.431*	– 0.338*	– 0.229*	0.624*	–	0.236*
	–	– 0.315*	0.238**	– 0.281*	–	0.643*	–	0.127*
Ethnicity	0.551*	–	– 0.360*	–	– 0.385*	–	–	–
	0.465*	–	–	– 0.193*	– 0.448*	–	–	–
	0.630*	–	– 0.293*	–	– 0.457*	–	–	–
Multiple jobs status	– 0.315**	–	–	0.181*	0.811*	– 0.463*	–	–
	0.281**	–	–	0.157**	0.566*	– 0.232**	0.121**	– 0.120**
	–	–	–	–	0.712*	– 0.492*	0.152*	–
Gender	0.189**	–	– 0.242*	–	0.167*	–	–	0.134*
	0.295*	–	– 0.237*	–	0.164*	–	– 0.134*	–
	0.560*	–	– 0.493*	–	–	–	– 0.237*	–
Age	–	–	–	–	0.018*	– 0.010*	–	–
	–	–	– 0.010*	–	0.013*	– 0.007**	–	–
	–	–	–	– 0.005**	0.015*	– 0.008*	–	–
Married & spouse employed	–	–	– 0.244**	–	0.273*	–	–	–
	–	–	– 0.405*	–	0.206**	– 0.262*	–	–
	–	0.148*	–	–	0.228*	– 0.261*	–	– 0.132*
Married & spouse unemployed	–	–	– 0.452*	–	0.443*	–	– 0.259*	–
	0.550*	–	– 0.751*	–	0.251**	–	– 0.179**	–
	–	–	– 0.305**	–	0.262**	– 0.377*	–	–
Suburb	–	–	–	–	– 0.167**	0.225*	–	–
	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–

Table 4 (continued)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
Non-metropolitan area	0.234*	–		–	–	–	–0.108**	–
	0.265**	–0.250*		–0.240*	–0.243*	0.270*	–	–0.129**
	–	–		–	–0.377*	0.350*	–	–
	0.303*	–0.130**		–0.240*	–0.531*	0.473*	–	–
Winter	–	–		–	–	–	–	–
	–	–0.114*		–	–	–	–	–
Work-only tour	–0.212**	–	0.209**	–	–	–	–	–
		–0.041*	1.059*	–0.119*				
		–0.051*	0.943*	–0.154*				
		–0.045*	0.914*	–0.095*				
Simple non-work tour								
Work-nonwork mix tour	–1.062*	–0.039*		–0.113*				
	–1.091*	–0.054*		–0.163*				
	–1.073*	–0.050*		–0.103*				
Complex non-work tour		–		–				
Work in home		–		–0.056*				
		–		–0.052*				
		–		–0.050*				
Work out of home	0.401*	–0.208*	0.568*	–0.276*	–0.605*		0.114*	0.135*
	0.381*	–0.199*	0.544*	–0.294*	–0.622*		0.124*	0.107*

Table 4 (continued)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
NW way to work	0.391*	− 0.215*	0.520*	− 0.263*	− 0.587*		0.104*	0.093*
	− 0.965*	− 0.035*	0.909*	− 0.102*				
	− 0.818*	− 0.040*	0.750*	− 0.122*				
	− 0.885*	− 0.041*	0.825*	− 0.085*				
NW during work	− 1.152*	− 0.042*	1.085*	− 0.122*				
	− 1.127*	− 0.056*	1.033*	− 0.169*				
	− 0.940*	− 0.043*	0.876*	− 0.091*				
NW way to home	− 0.759*	− 0.057*	0.715*	− 0.101*				
	− 0.775*	− 0.063*	0.711*	− 0.132*				
	− 0.786*	− 0.062*	0.732*	− 0.092*				
NW before work		0.284*		0.230*				
		0.342*		0.215*				
		0.364*		0.241*				
NW after work		0.316*		0.221*				
		0.344*		0.226*				
		0.362*		0.231*				
Work travel	–	–	–	–				
	0.582*	–	–	–				
	0.449*	–	–	–				
NW travel way to work	− 0.518*	− 0.019*	0.488*	− 0.055*				
	− 0.355*	− 0.018*	0.326*	− 0.053*				
	− 0.229**	–	0.213**	–				

Table 4 (continued)

From	To							
Variables	Work-only tour	Simple non-work tour	Work-nonwork mix tour	Complex non-work tour	Work in home	Work out of home	NW way to work	NW during work
NW travel during work	–	–	–	–				
	– 0.397*	– 0.020*	0.364*	– 0.059*				
	– 0.425*	– 0.020*	0.396*	– 0.041*				
NW travel way to home	–	– 0.057*	–	– 0.057*				
	–	– 0.049*	–	– 0.047*				
	– 0.269*	– 0.056*	0.250*	– 0.054*				
NW travel before work	–	–		–				
	–	– 0.705*		0.368*				
NW travel after work	–	–		0.236*				
	–	– 0.488**		–				

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
HH size	– 0.132*	– 0.065**	– 0.118*	– 0.208*	–	–	– 0.077*	–	–
			– 0.110*		– 0.028**		– 0.038**	– 0.088*	
			– 0.119*				– 0.071*	– 0.093*	
HH ownership		0.169**					– 0.154*	–	–

Table 4 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
No. of child aged 0–5	0.200*	0.185*	–	–	0.164*	–	–	0.139*	–
	0.139**	–	–	–	0.074**	–	0.134*	–	–
	–	–	–	–	0.185*	–	0.147*	–	–
No. of child aged 6–10	0.273*	–	–	–	0.082*	0.073**	0.150*	–	–
	–	–	0.319*	–	0.113*	–	0.092**	–	0.197*
	0.124**	–	0.182*	-0.161*	0.078*	–	–	–	0.142*
No. of child aged 11–18	0.120**	–	0.156*	–	–	0.062**	0.071**	–	0.132*
	0.199*	–	0.200*	–	0.098*	–	0.123*	–	0.165*
	–	–	0.212*	–	–	–	0.089**	–	0.211*
Low income (<$20 K)	–	-0.454*	-0.412*	–	–	–	-0.159**	-0.311*	–
	-0.226**	–	–	-0.233*	–	–	–	–	-0.262**
High income (>=$60 K)	–	0.231*	0.308*	-0.204*	-0.031*	0.123*	–	0.127*	0.286*
	–	0.144**	0.452*	-0.243*	-0.034*	0.136*	–	0.143*	0.326*
	–	0.206*	0.239*	–	-0.022*	–	–	–	0.197*
Employment type	–	-0.472*	-0.205**	0.293*	–	0.146*	–	-0.294*	-0.182*
	–	-0.343*	-0.288*	0.368*	–	0.178*	–	-0.276*	-0.192*
	–	-0.461*	-0.359*	0.347*	–	–	–	-0.314*	-0.249*

Table 4 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
Ethnicity	– –	–0.318*	–	–	–			– –0.241*	– –
Multiple jobs status	– 0.207* –	0.259* 0.221* 0.238*	–	–0.279*	0.083**	0.170*	–	0.246* 0.140** 0.238*	–
Gender	–0.307* –0.178* –0.361*				–0.122* –0.095* –0.195*	0.075**	–0.222* –0.185* –0.252*		
Age	– –0.006* –		–0.009* –0.011* –0.008*	–0.007* –0.004** –0.005*			–0.004*		–0.009* –0.006*
Married & spouse employed	– –0.266* –0.169**		–	–0.166* –0.164*			–0.155* –0.101**	–	–
Married & spouse unemployed	– –0.479* –0.230**		–	–0.238*	–0.156* –0.109**	–0.093*	–0.280* –0.138**	–0.205**	–
Suburb	– –0.163*	–0.163*		0.158*	0.087**		–	–0.145*	–

Table 4 (continued)

From — Variables	To — NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
	–	– 0.166**	–	–	–	–	–	– 0.128*	–
Non-metropolitan area	– 0.159*	– 0.298*	– 0.272*	–	– 0.075*	–	–	– 0.292*	– 0.193**
Winter	–	– 0.267*	– 0.291*	–	–	–	–	– 0.249*	–
	–	– 0.204**	–	–	–	–	–	– 0.176*	–
Work-only tour	–								
Simple non-work tour	–	– 0.101*	– 0.050*		0.068*	0.097*		– 0.078*	– 0.039*
Work-nonwork mix tour		– 0.086*			0.076*	0.081*		– 0.065*	
Complex non-work tour		– 0.069*			0.057*	0.065*		– 0.054*	
Work in home	0.271*	– 0.477*	– 0.267*	0.630*			0.157*	– 0.367*	– 0.203*
Work out of home	0.247*	– 0.465*	– 0.304*	0.632*			0.144*	– 0.352*	– 0.241*
	0.283*	– 0.429*	– 0.303*	0.630*			0.169*	– 0.334*	– 0.237*

Table 4 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
NW way to work					0.601* 0.608* 0.554*				
NW during work						0.720* 0.756* 0.705*			
NW way to home			−0.091* −0.071* −0.072*				0.579* 0.584* 0.598*		−0.069* −0.057* −0.056*
NW before work								0.770* 0.757* 0.779*	
NW after work									0.762* 0.795* 0.783*
Work travel									
NW travel way to work									
NW travel during work									
NW travel way to home			−0.157* −0.122*						−0.120* −0.097*

Table 4 (continued)

From	To								
Variables	NW way to home	NW before work	NW after work	Work travel	NW travel way to work	NW travel during work	NW travel way to home	NW travel before work	NW travel after work
NW travel before work			– 0.120*						
NW travel after work									– 0.094*

Only significant values are shown in the table for clarity of presentation. Each cell represents three coefficients for a pair of variables in 2006, 2009, and 2012 respectively

*: 5% level of significance, **: 10% level of significance; An empty dash (–) indicates that the variable is part of the model, but not significant; Blank cell indicates variable is not a part of the model

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