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A comparative analysis of discretionary time allocation for social and non-social activities in the U.S. between 2003 and 2013

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Abstract
We investigate changes in the allocation of discretionary time to social activities between 2003 and 2013 in the United States using data from the American Time Use Survey (ATUS). Within this period, several changes particularly around communication technologies have occurred, including the mass adoption of web and video enabled smart phones. Other advances include social networking platforms, low cost subscription based streaming movies, multi-person online gaming etc., which collectively can alter how people spend their discretionary time and their social activity time use. Summary statistics from the ATUS show a decline in the number of people reporting face-to-face social activities and a growth in the average leisure time spent alone between 2003 and 2013. At the same time, we observe modest declines in average time allotted to social activities and to mandatory activities. We separate time spent on discretionary activities into social activity time use and non-social activity time use and employ five doubly censored Tobit models to investigate time allocation for social and non-social activities between these two time points. These models show that the relative proportion of discretionary time allotted to face-to-face social activities has declined between 2003 and 2013. The apportionment of social to non-social time is also influenced by other sociodemographic variables such as gender, age, household structure, education and work hours. We summarize the implications of these findings to transportation and beyond.

Keywords Social activity participation · Face-to-face meetings · Time allocation · Technology and time use · American Time Use Survey

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Introduction

Social relationships are an important part of human lives. We rely on them for emotional and psychological health as well as for other social and economic reasons. People are born into some of these relationships, and they cultivate others over time, sometimes purposefully, with a functional end in mind, and other times without explicit intent. Face-to-face encounters are an important part of this relationship building. In many cases these meetings require an explicit time allocation decision and a tradeoff with other activities given the limited time people have over the course of a day or week. According to the 2013 American Time Use Survey (ATUS) people spent an average of 1.6 h engaging with others in the course of a 24-h period.

Urbanization, urban scale, and technology have all undoubtedly forced an evolution of how social interactions occur and at what geographic scale. Relationships today are increasingly global. It has never been easier to maintain regular communication with a geographically spread set of contacts at minimal cost. In today's urban areas, we regularly broach distances that would have been prohibitive a century ago. People regularly communicate with friends and family across countries or continents at minimal cost. The communication and transportation innovations that have enabled these no doubt have affected the allocation of time for social activities. They have altered the geographic scale at which people are able to maintain relationships, and are also likely to change our social time allocation decisions.

There are several reasons why social activity time use is of interest to a transportation audience. First, transportation can play important short term and long term roles in social activity decisions and social networks in general. In the short term, it can affect the duration, location, and timing of activities (Tilahun and Levinson 2017). Take for example two individuals, similar in every way except one has an automobile and the other relies on transit, and both seek an out-of-home in-person meeting. They will have to make different time allocation, location, and even time of day decisions, to accommodate differences in speed, service schedule, and coverage. In the long term, these social time use decisions can influence people's network structure and their network's geographic scale (Moore et al. 2013).

Second, technological changes may directly impact the decisions of how social activity is engaged. If more people shift to technology mediated meetings, that may mean less travel overall, or less travel for social activities and more travel elsewhere. It is important to discern these trends to understand both the nature and demand for travel. Third, the general movement towards increased adoption of activity based models of travel behavior makes time use analysis of importance to transportation. The choice of activities and schedule generation requires an understanding of when different activities are engaged, for how long, etc. In this paper, we are particularly interested in social activity participation and how it has (or has not) changed over time, along with discretionary time use, in a period that has seen dramatic changes in the adoption of internet enabled communication and entertainment technologies.

The paper focuses on the 10 year period between 2003 and 2013. A variety of technological innovations have taken place over this period that have altered and expanded our communications capabilities. The mass adoption of smart phones and hand held devices, the development of social networking sites, improved and reliable video chats, and better SMS experience have all occurred in this interim. The first iPhone and Android phones were released in 2007 and 2008 respectively, Facebook launched in 2004, Skype video started in 2006 and later became available on smart phones. In

addition, technology enabled personal entertainment that vies for some of our discretionary time have also shown considerable growth in the same period. These include streaming video services such as Netfilx which launched in 2008, and multi-player gaming on a variety of platforms which have proliferated. Some of these enhanced communication capabilities enable us to easily connect with others and even avoid travel for social engagement, while others help us fill (or expand at the cost of other activities) our "alone time" with on-demand entertainment.

Our intent in this study is to ask if time use between 2003 and 2013 has changed in ways that suggest technological changes have had an influence in social activity time allocation decisions. We hypothesize that time allocation has likely changed over this period. Specifically, we anticipate that in-person engagement would occur with less frequency and, when it occurs, durations would be shorter. We anticipate these for three reasons: (i) because ICT mediated meetings may replace some in person meetings, (ii) because the low cost of ICT may induce communication with a broader set of contacts, thereby reducing available time for each in-person meeting, and (iii) because expanded access to other technologies, such as on-demand entertainment, may lead to a higher amount of discretionary time being spent in non-social activities such as TV watching.

In making these hypothesis, we are mindful that the allocation of time to social activities depends on more than the technologies available. It will depend on household structure and responsibilities, life cycle, life style, constraints placed by work, and of course time allocated for basic human physical needs such as sleeping and eating. Outside of activities that one must do each day (such as caring for self and family, sleeping, eating, and working if employed), the division of time between remaining activities are (mostly) at the individuals discretion. At times this discretionary time has to be negotiated with others either inside the household or those outside with whom an activity is to be done together (e.g. when to meet, for how long, etc.). An observed allocation of time to such discretionary activities can be thought of as a reflection of the decision maker's preference over a set of time-use options (Yamamoto and Kitamura 1999). Its analysis is therefore amenable to the utilitarian framework in which choices are often analyzed in most econometric and transportation applications.

To explore these questions, we utilize the American Time Use Survey (ATUS) which has collected 24-h time use diary for successive years starting from 2003. We utilize a typology of activities discussed in Yamamoto et al. (2000) separating activities into mandatory and discretionary activities. Further we separate discretionary activities into social activities (involving others) and non-social activities. The choice of 2003 and 2013 is in part because of data availability and in part for the technological changes that have happened in the interim discussed earlier which have the potential to alter time use decisions. In investigating time allocation, first we look at summaries based on national data collected in 2003 and 2013 and investigate whether there has been a change in time allocation for social, non-social, and mandatory activities. Then we employ a doubly censored Tobit model as developed by Yamamoto and Kitamura (1999) to explore which socio-demographic variables inform trade-offs between social and other discretionary time.

The remainder of the paper is organized as follows: "Background" section provides a brief overview of time use analysis and models. That is followed in "Approach"section by a description of the modeling approach used. "Data" section describes the data used in this paper and provides summaries of observed time use for the two time points in this study. We then discuss five models that are estimated to look at time use in 2003 and 2013 in "Analysis" section and provide a summary and discussion in "Summary" section .

Background

Time use analysis in transportation is rooted in the early theoretical works by Becker (1965), DeSerpa (1971) where decisions are framed under constraints informed by time, budget, technology and minimum time requirements. This journal, Transportation, published three special issues on time-use analysis and related research on travel behavior in 1999, 2000 and 2002 (Levinson 1999; Gärling et al. 1999; Bhat and Misra 1999; Yamamoto and Kitamura 1999; Goulias 2002; Gliebe and Koppelman 2002; Pendyala et al. 2002), and many other recent studies have continued exploring this topic (Jara-Dfaz 2005; Farber and Páez 2009, 2010; Krueger et al. 2009; Wang and Law 2007; Moore et al. 2013, etc.), some of which have investigated the social dimension of time allocation, interactions with communication technologies, as well as auto-mobility.

A variety of factors affect time use decisions for different activities. Researchers have found that work time, including travel time to work, is an important factor that shapes other time use decision. Solberg and Wong (1992) for example find that time spent as part of the labor force for one-earner or two-earner household influences time apportionment for other activities. Some studies have looked at gender differences in time use (Sayer 2005; Mattingly and Blanchi 2003; Offer and Schneider 2011; Bianchi et al. 2000; Anxo et al. 2011; Manrai and Manrai 1995). They found that as women's time in education and occupational attainment has increased, their time devoted to paid work has also significantly increased. At the same time, women still spend a considerable time on unpaid work in activities such as housework and childcare, which result in less discretionary time than men (Sayer 2005).

Socio-demographic variables such as income, number of children, and household size also have impacts on people's social and leisure activity time allocation (Fernandez and Sevilla Sanz 2006). Poverty and hours of employment can limit people's ability to engage in leisure activities and thus exclude them from the society (Bittman 1999). More children at a younger age in the household would significantly increase women's time spent on childcare and decrease their time for leisure and other discretionary activities (Kimmel and Connelly 2007).

When meetings occur, allocation depends on factors beyond the persons scoio-demographics. Attributes of the meeting and the relationship are important in determining duration. For example, people allocate more time for pre-planned social activities than spontaneous activities (Berg et al. 2012). Social engagement also varies by people's different role in the relationships (leader vs. follower) and type of relationship (family vs. friends) (Deutsch and Goulias 2013). Gliebe and Koppelman (2002) consider the interpersonal relationships within household by comparing a multinomial logit model versus a linked-decision-maker model. The authors find that the time allocation to independent and joint out-of-home activities (maintenance, subsistence and leisure) with adult household members will be affected by the employment status, mobility in terms of auto ownership, and presence of children especially pre-school children. Tilahun and Levinson (2017) employed a path analysis to look at how household characteristics and relationship strength influence people's location, duration, and distance travelled for social activities. They find that meeting with close contacts tend to increase the social activity duration as well as the distance one is willing to travel for such meetings when they occur outside of the home.

Studies have looked at how communication and computing technologies have re-shaped people's time schedule (Vitalari et al. 1985). Some find that more time spent on computer use is likely to decrease people's leisure time spent with others and that this is having larger impact on household with children (Vitalari et al. 1985). Nie and Hillygus (2002) separated

the time spent on the internet at home and work and on weekdays and weekends. Their study found that time on the internet at home or on weekends has a strong negative impact on people's face-to-face social activities, while time on Internet at work or on weekdays does not have such impact. Dong et al. (2018) used the American Time Use Survey to look at time spent on computers as leisure activities. They find weekend leisure activities outside the home are associated with less time spent on communicating via social networks.

Various studies have looked at different aspects of time use decisions. These studies look at whether different types of time-use affect each other or whether particular types of time use are affected by urban form or other variables. For example, Fan and Khattak (2009), Lin and Wang (2014) look at time use by whom people meet. They find different impacts of urban form on people's solo and joint social and recreation activity time use (Fan and Khattak 2009). Levinson (1999) distinguishes the time for travel and time for other activities and investigates their relationship. Other studies have looked at time for mandatory and discretionary activities while separating activity locations as in-home and out-of-home. Schwanen and Dijst (2003) examine how time allocation to out-of-home non-work activities and associated travels are influenced by the fixed work and in-home activities on workdays. Meloni et al. (2004) look at factors influencing in-home and out-of-home time allocation of discretionary time while Spissu et al. (2009) conduct a similar research but looking at weekly time allocations to out-of-home discretionary activities. Kitamura (1984) investigates time allocation to discretionary out-of-work activities for workers on non-work days.

Analysis by Bhat and Koppelman (1993, 1994); Bhat and Misra (1999) have looked at the generation of in-home and out-of-home activities focusing on household needs. They categorize the daily activities into subsistence and maintenance, based on Reichman's typology of time use structures. The empirical analysis indicates that there are interdependencies between weekday and weekend time use, and that working hours and age play significant roles in determining time allocation. Other research has looked at the apportionment of discretionary time between in-home and out-of-home activities or how Yamamoto and Kitamura (1999) examine the allocation of discretionary time allocation for in-home and out-of-home activities on work and non-work days employing a doubly censored Tobit model. Among the variables they test, they find for example that commute time doesn't influence how discretionary time is split between in-home and out-of-home activities and that higher vehicle ownership is associated with more out-of-home activities. They also note variations based on household size and significant intra-person variation across days. Fujii et al. (1999) examine joint participations in social activity. The authors find that full-time workers and housewives spend more time in-home with family members, but workers have higher meeting frequencies for out-of-home activities with families. In addition, they find that income encourages out-of-home activities both alone and with family members. Farber and Páez (2009) look at the impact of income on time allocation and conclude that low income families prefer in-house social activities than out-of-home activities probably due to the lower travel costs.

Gliebe and Koppelman (2002) consider the interpersonal relationships within household by comparing a multinomial logit model versus a linked-decision-maker model. The authors find that the time allocation to independent and joint out-of-home activities (maintenance, subsistence and leisure) with adult household members will be affected by the employment status, mobility in terms of auto ownership, and presence of children especially pre-school children.

Work on time use analysis has classified time-use in different ways. The approach often assumes a utility maximizing individual making decisions over time divisions to different

activities. In this paper we use the approach developed in Yamamoto and Kitamura (1999) for discretionary in-home and out-of-home activities and apply it to time allocation for social meetings and non-social activities in our case. The methodology is discussed in the "Approach" section.

Approach

In this study, we separate time allocation for discretionary activities into social activities and non-social activities. We assume that each decision maker has some time T available for discretionary activities that they can apportion to various purposes. We classify these purposes broadly as social (activities that involve others) and non-social activities and view allocation of discretionary time to either category as a result of a utility maximizing decision making process which is formulated as follows (except for the activity type, the formulation below is as appears in Yamamoto and Kitamura (1999)):

$$U_j(t_j, X_j) = \begin{cases} \xi_j V_j(t_j, X_j), & \text{if } t_j > 0. \\ 0, & \text{if } t_j = 0. \end{cases} \tag{1}$$

where U_j is the utility from participating in activity j, ξ is a positive random variable associated with activity j, t_j is the time allocated for the activity and X_j is a vector of exogenous variables affecting the utility of time allocated to activity j. The person making an allocation decision between t_1 and t_2 for two types of activities then maximizes:

$$\begin{aligned} &U(t_1, t_2) = U(t_1, X_1) + U(t_2, X_2) \\ &\text{subject to: } t_1 + t_2 = T \\ &\quad t_j \geq 0; j = 1, 2 \end{aligned} \tag{2}$$

where t_1 and t_2 represent the division of time to non-social and social activities and T represents the total discretionary time available to the person. Letting V_j take the form:

$$V_j(t_j, X_j) = \alpha_j log(t_j) \tag{3}$$

and solving the maximization problem, the optimal levels of t_1, t_2 are:

$$\begin{aligned} t_1^* &= \frac{\xi_1 \alpha_1}{\xi_1 \alpha_1 + \xi_2 \alpha_2} T \\ t_2^* &= \frac{\xi_2 \alpha_2}{\xi_1 \alpha_1 + \xi_2 \alpha_2} T \end{aligned} \tag{4}$$

If one were to take the natural log or the ratio of t_2^* to t_1^* then:

$$log(t_2^*/t_1^*) = log(\alpha_2) - log(\alpha_1) + log(\xi_2) - log(\xi_1) \tag{5}$$

Letting:

$$\begin{aligned} &\beta' X = log(\alpha_2/\alpha_1), \text{and} \\ &\quad \epsilon = ln(\xi_2/\xi_1), \text{where } \epsilon \sim N(0, \sigma^2) \end{aligned} \tag{6}$$

we can rewrite:

$$log(t_2^*/t_1^*) = \beta' X + \epsilon \tag{7}$$

As Yamamoto and Kitamura (1999) note, when a person engages in both social and non-social activities, this implies that the utility that they would have in allocating all discretionary time (T) solely to t_1 or t_2 is less than that they would get from apportioning total T to just one of the activities. When time is allocated to one activity alone, the utility from allocating it to this activity must be greater than partitioning it, or alternately allocating all time to the second activity. They also show that allocation time to two discretionary activities (t_1 and t_2) can be written as a doubly censored Tobit model with individual level thresholds $\log \upsilon_{1i}$ and $\log \upsilon_{2i}$ as follows:

$$y_i^* = log(t_{2i}/t_{1i}) = \beta' X_i + \epsilon_i$$

$$y_i = \begin{cases} \log \upsilon_{1i}, & \text{if } y_i^* \leq \log \upsilon_{1i} \\ y_i^*, & \text{if } \log \upsilon_{1i} < y_i^* < \log \upsilon_{2i} \\ \log \upsilon_{2i}, & \text{if } y_i^* \geq \log \upsilon_{2i} \end{cases} \tag{8}$$

where y_i^* is a latent variable whose values can be observed when $\log \upsilon_{1i} < y_i^* < \log \upsilon_{2i}$ for each individual i. The lower and upper limits $\log \upsilon_1$ and $\log \upsilon_2$ are individual specific and can be determined from data. These values depend on the total discretionary time (T) that an individual has. See Yamamoto and Kitamura (1999) for details of how to compute $\log \upsilon_1$ and $\log \upsilon_2$.

Data

The American Time Use Survey (ATUS) has been collected annually starting from 2003 by the Bureau of Labor Statistics. This work uses the 2003 and 2013 data. The data contains information about each respondent's activity episode within a 24-h period including time use, activity type, location, and also who was accompanying the respondent for each activity. We categorize the activity episodes into one of three activity types: mandatory activities, social activities (involving others), and all other activities outside of mandatory and social activities. Mandatory activities are those whose timing, durations or location are predetermined, those the individual has to perform to function, and those activities engaged in the care of household members. We classify eating, sleep, education, work, and personal and childcare for household members into this category. We classify the remaining time as discretionary time and further divide it into social activity and non-social activity. Activities grouped under the social category are face-to-face engagements with others and non-face-to-face allocations to interact with others. What we classify as a face-to-face social activity is (1) any time that is spent with another person (a household member or otherwise) when occurring outside of the home of the respondent, and (2) time spent with at least one individual that is a non-household member when occurring inside the home of the respondent. In both cases the time must also be identified as social activity time in the ATUS activity code or identify the individual is engaging in sport activities that involve others (playing golf, etc.). The broader social activity category includes face-to-face activities as well as non-face-to-face communications with others. One limitation is that ATUS data categorizes web-based internet use as a leisure activity and does not separately account for any web based social activities that may have occurred.

All other activities that are not part of the mandatory or social time use are grouped under non-social discretionary time. These include time use for alone leisure time, consumer purchases, civic obligations, sports/exercise/recreation, religious activities, volunteer activities, etc.

Our analysis of time use focuses only on civilian respondents who live in a metropolitan area, and lived in sedentary housing (apartments, houses, flats etc.). We also focus on data collected on non-holiday days and those individuals who were over 18 years of age at the time of the survey. The sociodemographic summary for the respondents used in the analysis is given in Table 1. In both periods (i.e. 2003 and 2013), nearly half the observations were made during a weekend. In addition, approximately 4 out of 10 respondents reported working on the day of their survey and approximately 3 in 10 were not in the labor force at the time of the survey. The data has more women than men and fewer than 3 in 10 reported living alone during the survey day.

Analysis

Time use summaries

In analyzing the data, we first provide a summary of the aggregate time use trends observed in the data. This part of the analysis uses the sampling weights provided in the data. The

Table 1 Socio-demographic summary of sub-sample used in analysis

	ATUS 2003			ATUS 2013		
	Mean	SD	Median	Mean	SD	Median
Age	46.12	16.03	44.00	49.12	16.86	48.00
Household size	2.78	1.47	2.00	2.64	1.48	2.00
# children und. 4	0.17	0.46		0.15	0.43	
# children 5–13	0.45	0.80		0.42	0.78	
Income	$51437	$28776	$44999	$66198	$49759	$54999
	Proportions			Proportions		
Sex (male = 1)	0.44			0.45		
Lives alone	0.21			0.27		
Household has children	0.45			0.41		
Respondent not in labor force	0.28			0.32		
Spouse works full time	0.34			0.29		
Ed: Less than high school	0.12			0.10		
Ed: High school graduate	0.26			0.24		
Ed: Some college	0.19			0.18		
Ed: Associate Degree	0.09			0.1		
Ed: Bachelors Degree	0.21			0.24		
Ed: Graduate/Prof. School	0.13			0.15		
Surveyed weekday	0.49			0.50		
Worked on survey day	0.39			0.37		
# Observations	13097			8445		

allocation of time to different activity types is shown in Table 2 separately for 2003 and 2013. In many cases, allocation of time across the period, has not changed in very large ways. We note some reductions in average social time and mandatory time, totaling about 10.6 min, and an equivalent increase in the average non-social discretionary time. Taking a closer look, we observe two prominent changes in the data relating to the proportion of face-to-face meetings and the amount of time spent in alone-leisure time. As can be seen from the table, the proportion of people reporting a face-to-face (F2F) social activity shows a substantial decline from 48% in the 2003 data to 43% in 2013. This suggests a significant reduction in activity participation rates and accounts for the drop in the overall average face-to-face meeting time. However, despite this change, when looking at time allocation among those who had face-to-face activities, we do not observe much difference in the average allotted time for such activities. This is also true for overall social discretionary time, which has a significant drop when all respondents are considered, but among those who had social discretionary time, the average has remained stable. Average non-face-to-face social time has also remained quite similar between 2003 and 2013 at around 40 min.

Table 2 Weighted time use summaries in minutes by activity type

	ATUS 2003			ATUS 2013		
Activtity	Mean	SD	Median	Mean	SD	Median
Mandatory	952.79	247.35	960.00	949.67	250.92	950.00
Mandatory (no children)	914.72	250.29	890.00	905.90	250.89	870.00
Mandatory (with children)	1010.38	231.25	1035.00	1027.86	231.24	1060.00
Mandatory (non-workday)	795.12	192.21	775.00	795.47	194.99	773.00
Mandatory (workday)	1131.52	168.92	1155.00	1141.68	165.94	1169.00
Social discretionary	92.98	144.03	20.00	85.49	142.16	10.00
Social discretionary (>0)	167.70	157.75	120.00	166.28	160.87	120.00
Prop. w. F2F activity	0.48	0.50	0.00	0.43	0.50	0.00
Social (F2F, All)	86.10	142.13	0.00	79.46	141.37	0.00
Social (F2F > 0)	180.59	159.09	135.00	182.73	164.59	135.00
Social (F2F > 0, lives alone)	188.82	158.06	150.00	193.98	163.10	150.00
Social (F2F > 0, HH size>1)	179.09	159.25	135.00	180.45	164.83	130.00
Social (F2F > 0, non-workday)	225.87	174.54	182.00	222.84	178.18	180.00
Social (F2F > 0, workday)	119.19	108.53	90.00	121.58	117.56	90.00
Social (NF2F)	6.88	23.52	0.00	6.03	20.44	0.00
Social (NF2F > 0)	39.72	43.47	30.00	39.56	37.64	30.00
Social (NF2F > 0, lives alone)	46.69	47.37	30.00	47.75	45.03	30.00
Social (NF2F > 0, HH size > 1)	37.91	42.22	30.00	37.33	35.07	30.00
Non-social discretionary	394.23	239.13	360.00	404.84	243.33	370.00
Leisure (alone)	119.7	163.56	60.00	133.22	181.42	60.00
Leisure (alone, not in Lab. F)	190	214.29	120.00	208.01	229.61	120.00
Leisure (alone, in Lab. F)	93.77	131.11	45.00	100.3	143.72	45.00
Leisure (alone, lives alone)	249.1	216.37	195.00	272.19	228.36	225.00
Leisure (alone, HH size > 1)	98.4	142.28	40.00	108.51	159.53	44.00

* *F2F* face-to-face activities; *NF2F* non-face-to-face activities; *Lab. F* in labor force;

Social discretionary > 0, F2F > 0, NF2F > 0: when people spend time on such activities

This time includes phone calls to friends and families and time on email. As noted earlier, time spent on the internet chatting or socializing is not captured separately as a social activity in the ATUS data and thus not categorized in the non-face-to-face social category in this study.

Where we observe rather large increases in time allocation is in leisure alone time. Time spent alone in a leisure activity includes activities such as watching TV, reading, browsing the internet, etc. where the respondent was alone. This time component constitutes a large proportion of the total non-social discretionary time. As the numbers in Table 2 show, this time has increased substantially from 119 min in 2003 to 133 min in 2013 for the average respondent. The time is particularly large for those not in the labor force as well as those who report living alone. In every category we have looked at here, the allocation of time to leisure alone activities seems to have increased in the range of 7–11% over 2003 levels. The largest increase of 23 min is observed among those living alone. This is consistent with our expectations given the proliferation of on-demand entertainment options that many people now have access to. While some of the increases in leisure alone time may have come from the reductions in social and mandatory times, some likely also came from a realignment of how non-social discretionary time is spent.

Overall, we observe that the average non-social discretionary time has increased by 10.6 min between 2003 and 2013 (2.7%) while averages for social time and mandatory time have dropped by 7.5 min and 3.1 min. Beyond the average changes, these values don't tell us much about how different socio-demographic factors are related to changes in time allocation. In the next section, we investigate what factors affect the allocation of discretionary time to social and non-social activities following the methodology discussed in "Approach" section. While we can not pinpoint the causes of any changes in this analysis, our goal is to see if patterns exist that may suggest a change in time use consistent with the technological changes that have occurred (e.g. widespread smart phone use, online social networking). In the next section we describe the estimated model using the ATUS data.

Allocation of time for social and non-social activities

Following the discussion in "Approach" section, we take t_{2i} to be the time allocated to social activities (t_{si} going forward) and t_{1i} to be the time allocated to all other activities hat fall outside of mandatory activities and social activities (t_{oi} going forward) so the linear component of our model becomes:

$$log(t_{si}/t_{oi}) = \beta' X_i + \epsilon_i$$

We assume the linear component $\beta' X_i$ depends on the persons socio-demographic characteristics, their employment status, and whether they had to work on the day their time use was recorded (including how many hours they worked). We incorporate work time here because it is the type of mandatory activity that doesn't necessarily occur every day and because for many, it requires that some time be spent out of the home. We also anticipate that the additional pressure it creates on the discretionary time forces tradeoffs between social and non-social activities. This can happen for example, if social activities require some minimum time allocation and a narrower discretionary time (as a result of work activity) may force decision-makers to move away from such time use. We model the linear component as follows:

$$\beta' X_i = f(A, S, I_{pc}, W, L, AI, C, F_s, E, H_w, Y)$$

where A Age of the respondent; S Sex (1 = Male, 0 = Female), I_{pc} Household income divided by household size; W Time use was collected on a weekday (1 = Mon–Fri, 0 = Sat–Sun); L Individual is not in labor force (1 = True, 0 = False); Al Individual lives alone (1 = True, 0 = False); C Number of children under 18 in the household; F_s; Respondents spouse works full time; E Education level—has six levels (E_{lh}: Less than high school, E_h high school graduate, E_{sc}: Some college, E_{ad}: Associate Degree, E_b: Bachelor's Degree, E_g: Graduate degree or professional degree); H_w Hours of work reported in the day; Y Year data was collected.

We estimate and report on five models below each of which correspond to (1) the 2003 data, (2) the 2013 data, (3) the 2003 and 2013 combined data, (4) the 2003 and 2013 combined data only for work days, and (5) the 2003 and 2013 data only for non-work days. We model age as quadratic functions to estimate any non-linearity that may be present. The dependent variable is $\log(t_s/t_o)$ and positive estimates imply that allocation of discretionary time to social activity increases with a variables increase and negative estimates imply that time allocation to social activity decreases relative to other activities. Model estimation was done using the rootSolve library (Soetaert 2009) to find the individual specific censoring limits $\log \upsilon_1$ and $\log \upsilon_2$ and the VGAM package (Yee 2014) for the Tobit regression in R (Core Team 2014). The models are presented in Table 3.

The goodness of fit statistics for all models suggests that each performs significantly better than the intercept only model. Many of the socio-demographic variables are also significantly related to the allocation of time to social activities. The model estimates for 2003 and 2013 (model 1 and model 2) have parameters that are very close to each other for each of the variables considered. In addition, all of the significant variables have the same signs suggesting the direction of influence for these variables has remained the same between 2003 and 2013. A comparison of the reported models against models without the year variable using a likelihood ratio test suggested that year was an important variable to keep. The negative sign for the year in models 3, 4, and 5 suggests that there has been a decline in social time allocation relative to non-social time by 2013 as compared to 2003 levels, all other things equal.

Looking at the covariates, we observe that the ratio of social to non-social time is higher for women than men suggesting that women are more likely to have a higher social to non-social time ratio than men. Age has a quadratic relationship with the amount of time allocated to social activities. The apportionment of time to social activities declines initially but changes pattern once respondents are in their 60s and subsequently rises. The ratio of social to non-social time is smaller on weekdays than weekends and it is also smaller for those who are not in the workforce, all other things equal. As the time allocation summaries in Table 1 showed, people who were not part of the labor force spent over twice the amount of time on alone-leisure activities than those who were in the labor force, in part accounting for the smaller t_s/t_o ratios for this group. Income per household size is significant and has approximately the same positive relationship with t_s/t_o ratios for all five models suggesting that wealthier households are able to allocate more time to social activities relative to time spent on non-social activities.

Household structure also plays a role in how discretionary time is apportioned between social and non-social activities. Living alone in particular has a large impact on the ratio between social and non-social time. As Table 1 showed, those who live alone have approximately three times the time allocation for alone-leisure activities (such as watching TV, browsing the web, reading etc.) as compared to those in multi-person households. Respondents whose spouses have full time jobs tended to allocate a lower time to social activities. In addition, the number of children (as well as the presence of children) under

Table 3 Models for time allocation for social and other discretionary activities

	Year 2013		Year 2003		2003 & 2013		2003 & 2013		2003 & 2013	
	All days		All days		All days		Workdays		Non-workdays	
Variable	Est.	*p* val	Est.	*p* val	Est.	*p* val	Est.	*p* val	Est.	*p* val
Intercept	1.377	0.000***	1.333	0.000***	1.351	0.000***	1.362	0.000***	1.344	0.000***
S (Sex)	− 0.471	0.000***	− 0.370	0.000***	− 0.415	0.000***	− 0.305	0.002**	− 0.469	0.000***
A (Age)	− 0.119	0.000***	− 0.128	0.000***	− 0.128	0.000***	− 0.148	0.000***	− 0.125	0.000***
A^2 (Age^2)	0.001	0.000***	0.001	0.000***	0.001	0.000***	0.001	0.000***	0.001	0.000***
I_{pc}(*Inc./hhsiz*)	0.007	0.001***	0.006	0.021*	0.007	0.000***	0.007	0.009**	0.008	0.000***
W (*Weekday*)	− 0.596	0.000***	− 0.581	0.000***	− 0.587	0.000***	− 0.216	0.057.	− 0.751	0.000***
L (*Lab.Force*, 1 = *N*)	− 0.442	0.001***	− 0.196	0.061.	− 0.298	0.000***	–	–	− 0.180	0.040*
Al (*livesalone*)	0.567	0.000***	0.681	0.000***	0.627	0.000***	0.629	0.000***	0.647	0.000***
C (children, < 4 [a])	− 0.289	0.014*	− 0.454	0.000***	− 0.397	0.000***	− 0.400	0.000***	− 0.403	0.000***
C (children, 4–13[b])	− 0.197	0.004**	− 0.167	0.001***	− 0.170	0.000***	− 0.145	0.025*	− 0.198	0.000***
F_s (spouse FT, 1 = Y)	− 0.186	0.119	− 0.210	0.014*	− 0.194	0.005**	− 0.204	0.065.	− 0.203	0.024*
E_h	− 0.067	0.708	0.241	0.057.	0.128	0.217	− 0.056	0.793	0.145	0.219
E_{sc}	0.150	0.429	0.343	0.011*	0.270	0.013*	0.048	0.827	0.279	0.029*
E_{ad} (Education[c])	− 0.002	0.994	0.249	0.130	0.146	0.261	− 0.048	0.844	0.158	0.309
E_b	0.387	0.040*	0.195	0.162	0.268	0.016*	− 0.311	0.151	0.506	0.000***
E_g	0.559	0.007**	0.482	0.002**	0.507	0.000***	0.009	0.969	0.707	0.000***
H_w (work hours)	− 0.113	0.000***	− 0.079	0.000***	− 0.092	0.000***	− 0.148	0.000***	–	–
Y (year = 2013)	–[d]	–	–	–	− 0.349	0.000***	− 0.383	0.000***	− 0.327	0.000***
logLik(0)	− 15515.64		− 25048.82		− 40584.03		− 14037		− 26515.14	

Table 3 (continued)

	Year 2013		Year 2003		2003 & 2013		2003 & 2013		2003 & 2013	
	All days		All days		All days		Workdays		Non-workdays	
Variable	Est.	*p* val	Est.	*p* val	Est.	*p* val	Est.	*p* val	Est.	*p* val
logLik	− 15312.35		− 24711.48		− 40043.19		− 13843.09		− 26174.76	
− 2(Δ*LL*) (DF)	406.58 (18)		674.68 (18)		1081.7 (19)		387.82 (18)		680.76 (17)	
N	8445		13097		21542		8252		13290	

Signif. codes: ***0.001; **0.01; *0.05 . 0.1

[a]Number of children under 4 years old

[b]Number of children between 4 and 13 years old

[c] E_{lh}: Less than high school, E_h: High school graduate, E_{sc}: Some college, E_{ad}: Associate degree, E_b: Bachelor's degree, E_g: Graduate or prof. degree

[d]–: not applicable

13 years of age was significant in all of the models, with different magnitude of impact for different age groups. Respondents with more children under 4 years old will have lower ratio of social to non-social time. The number of younger children (under 4 years old) has larger impact on the time allocation for social activities than older children (between 4 and 13 years old). The number of children between 14 and 18 years old was not significant and dropped from the model.

The Education variable also has some impact on the apportionment of time to social activities. As compared to the category of less than high school, the impact of associate college is significant in the 2003, combined model and the non-workday model. People with higher educations (with bachelors' or graduate degrees) tend to spend more time on social than non-social activities, except for the combined workday model. In the workday model, education at all levels has no impact on the time ratio, which may be because main constraint on workdays is the working hours.

Those who spent more hours at work had lower time allocated to social activities relative to non-social activities. This maybe because more hours at work limits the available overall discretionary time and because social activities are likely to require some minimum time allocation, the narrower discretionary time may make it easier to engage in non-social activities on such days. As discussed earlier, the changes to allocation of time as implied by the year variable suggest that people's allocation of time to social activities were smaller in 2013 than in 2003, all other things equal.

Summary

This study investigated changes to time allocation for social activities using national time-use data from the U.S. collected in 2003 and 2013. We pick these two time points in part because of data availability and in part for the technological changes, particularly in mobile devices as well as online social network communication that have occurred in the interim, with the potential to affect how people interact with one another. Summary statistics show that largely the allocation of time to mandatory activities has remained stable, while average social time has shown a modest decline, and average non-social time has increased. We also observe fewer people who have reported a face-to-face meeting in 2013 as compared to 2003. When face-to-face meetings occur, however, the time spent on such activities has not changed significantly. We observe larger shifts in the average time allocated to subcategories of non-social time. In particular, leisure time alone was significantly larger in 2013 as compared to 2003, at times by as much as 30–40 min over a 24 h period.

We also employ five doubly censored Tobit models to look at the relationship between time allocation for social and non-social activities and the socio-demographic characteristics of individuals. In the models we estimated, patterns of time allocation using 2003 and 2013 data separately produced largely similar estimates for different socio-demographic variables. Models that combines the 2003 and 2013 data suggest controlling for year is important, where individuals on average apportioned smaller time to social activities in 2013 as compared to 2003.

Individual variables such as age and sex, household variables such as living alone or having a spouse that works full time had varying level of impact on the ratio of allocation of time to social vs. other activities. The presence of younger children (under 4 years old) appears to have larger impact on the ratio of social to other-discretionary time than the present of older children (between 4–13 years old). It on average lowers the

time spent on social activities. Work hours, which count toward mandatory activities, also lowered the apportionment of time to social activities.

Some of these findings are similar to findings in other time use studies as to which variables are influential in time allocation decisions while other aspects differ markedly. For example, Yamamoto and Kitamura (1999) note that in apportioning in-home or out-of-home activities, income and working hours were not significant predictors. In contrast, here we find both income and working hours to be important in how discretionary time is apportioned between social and non-social time, with higher income individuals having more social time but work hours having a negative influence on apportionment towards social time. In both studies, the presence of children was an important factor in time use allocation, increasing in-home time allocation in (Yamamoto and Kitamura 1999), and reducing social time in our study. Fujii et al. (1999) finds workers spend more time at home than out of home. Here we find those in the labor force apportion less time to social activities. Farber and Páez (2009) find that low income families prefer in-house social activities than out-of-home activities. In this study, we find that the ratio of social to non-social activities was lower for lower income households as compared to higher income households. These findings suggest that social time use has its own unique characteristics and call for more studies to understand the factors affecting it and the changes it is undergoing.

Overall, the study finds a lower rate of face to face social activity participation in 2013 as compared to 2003. However, when social activities occur, their duration on average has not changed between 2003 and 2013. Further, leisure time spent alone has significantly increased for many people. We also find that the ratio of social to non-social time allocation in 2013 as compared to 2003 has declined. One limitation of the study is that the data does not allow us to identify social activities that may have been web based as these are not explicitly coded.

Taken together, the study suggests that there have been marked changes in the allocation of time to social activities between 2003 and 2013. One important dimension of this is that the proportion of people participating in social activities is fewer in 2013 as compared to 2003. This finding has several implications. From the transportation point of view, the reduction in the number of people undertaking social activities suggests a reduction in social activity travel. One possible implication of this is that there is less travel occurring overall, as might be the case if much of the transfer is towards in home alone activities. Or perhaps a shift is occurring among these individuals towards other activities which engender their own travel. The findings call for more work to understand how the demand for travel is shifting. Second, it highlights the need for more frequent data collection, particularly of data inputs to decision making models, when there are rapid changes in technology and when there is reason to believe those changes may affect travel behavior.

Beyond the transportation implications, it is also important to examine whether these changes (i.e. less social activity participation, higher alone leisure time) arise simply from shifting preferences or from different types of economic or social hardships, as the latter may have implications to health, mobility, overall wellbeing, or life satisfaction. For example, in a recent study among the elderly, many of whom had some type of disability and mobility limitations, we found that higher levels of leisure alone time and higher ICT mediated social activities were associated with lower levels of life satisfaction (Li and Tilahun 2017). These possibilities call for an examination of whose social activity participation rates have fallen, why, and if any transportation, technological, health, or other interventions are called for.

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