The Role of the Internet in Shaping Young Adults' Attitude, Travel Choices and Sustainable Lifestyles: A Longitudinal Perspective

Guoqiang Wu[1]

Ph.D. Candidate (Urban Studies)
School of Social and Political Sciences, University of Glasgow
7 Lilybank Gardens, University of Glasgow, Glasgow, UK G12 8RZ
Email: g.wu.1@research.gla.ac.uk; Tel: +44 (0) 141 330 2893

Jinhyun Hong

Lecturer (Urban Studies)
School of Social and Political Sciences, University of Glasgow
7 Lilybank Gardens, University of Glasgow, Glasgow, UK G12 8RZ
Email: Jinhyun.Hong@glasgow.ac.uk; Tel: +44 (0) 141 330 7652

Piyushimita (Vonu) Thakuriah

Professor (Urban Studies) and Director (Urban Big Data Centre)
School of Social and Political Sciences, University of Glasgow
7 Lilybank Gardens, University of Glasgow, Glasgow, UK G12 8RZ
Email: piyushimita.thakuriah@glasgow.ac.uk; Tel: +44 (0)141 330 4079

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[1] Corresponding author

ABSTRACT

Young people's mobility behavior and its association with ICT (Information and Communications Technologies) usage have been massively researched. Few studies, however, have considered the impacts of past ICT usage on young people's current travel patterns. This study contributes a novel analysis by exploring the effects of past habits of Internet usage in adolescence on young adults' sustainable travel choices, with consideration of the intermediary effects caused by their environmental attitude. Pro-environmental behavior is also modeled to assess the overall sustainability of their lifestyles. Based on the 2004 British Household Panel Survey (BHPS) and the Understanding Society survey (Wave 4, 2012/14), structural equation modeling (SEM) was applied to examine the complex interrelationships among young adults' Internet usage (past and current), travel choices, environmental attitude and behavior. The findings reveal that young adults with high-frequent Internet use tend to have more sustainable travel patterns (e.g. less car use and more use of public transport) and a more positive attitude to the environment, and behave in a more environmentally friendly way. Such Internet-induced effects on travel choices and pro-environmental behavior are even more pronounced for the experienced heavy users – i.e. those who keep the heavy Internet use habit formed in their early years. Their environmental attitude, which is profoundly shaped by their long-term exposure to the Internet, indirectly and greatly contributes to the effect of the Internet as a mediator on their choices and behavior

INTRODUCTION

Millennials – i.e. people born in the last two decades of the 20th century – have been the focus of much research across various fields. They are reported to have different attitudes, behavior, consumption patterns and lifestyles from earlier generations at the same life stage. In transportation research, millennials are found to exhibit lower rates in both possessing a driver's license and car ownership (1–3), drive less (4–6), use alternative modes more often (2,7,8), and generally undertake fewer trips and travel fewer miles on a daily basis (5,9). Apart from dramatic socioeconomic changes, such as delayed marriage and transition into adulthood, which contribute to seemingly more sustainable mobility patterns such as bicycling or walking, those who were born after 1980 were exposed to digital technologies from a young age and used such technologies to a much greater degree in their everyday lives, compared with earlier generations (10). Further, their heavy reliance on Information and Communication Technologies (ICT) in daily life has largely reshaped their transportation needs and travel behavior (11). Aside from these longer-term societal patterns, disruptive economic conditions such as the recession may have led to their lower adoption of driving, due to higher costs of car ownership and car insurance rates for younger people (12,13).

A large number of studies have considered the impact of ICT on human travel/activity, particularly its potential for substituting physical travel with virtual activities (teleworking, e-shopping, online socializing, etc.). In addition, the application of ICT in the transportation sector has brought about various technology-enabled transportation services and tools, such as real-time information provision, car-sharing apps and on-board Wi-Fi, which make public transit, cycling, ridesharing and other modes more attractive to travelers, thereby reducing car use (2,14,15). Millennials seem to be more susceptible to such ICT-induced effects as they are 'digital natives' (born and raised in the digital era) and more tech-savvy than earlier generations (2,16,17).

Attitude may also mediate ICT-induced impacts on travel behavior. Much research on millennials' mobility patterns and travel choices has considered their environmental attitudes and concerns (2,16,18), as millennials are often described as more committed to sustainability and environmental protection (16). These studies generally concluded that a pro-environment attitude correlates to millennials' sustainable travel behavior (including less car use and more use of other modes of transport) – a conclusion consistent with the classical behavioral theories such as the theory of planned behavior, the norm-activation theory and the

value-belief-norm theory, which all highlight the causal link between attitudinal factors and behavior, and have been widely applied to explain human travel behavior, particularly travel-choice behavior (19,20). Based on the attitude–behavior relationship, attempts have been made to direct behavioral changes towards more sustainable patterns through influencing attitudes, and ICT was found to be effective in exerting such influence. For example, the Internet, as an information depot, can increase people's environmental consciousness and awareness through information spreading and knowledge provision (21–23). Additionally, researchers have looked at the Internet as a tool for environmental activism and organization, highlighting its potential to enhance environmental activism and governance (23–25). In millennial studies, Allen, Wicks and Schulte (26) revealed that young citizens tend to use online social networks to convince their peers to be more environmentally friendly, and such peer persuasion can generate subjective norms that ultimately may influence behavior (26). This finding seems to reinforce the emerging theory of captology (i.e. the study of computers as persuasive technologies), which highlights ICT's role of persuasion in changing people's attitudes and behavior (27). The relationships between ICT use and behavior, and between attitudes and behavior, have been well studied for understanding millennials. However, the ICT-induced influences on millennials' attitudes, and the intermediary role attitude plays between ICT use and behavior, have received little attention. This study attempts to fill the gap in this causal link by exploring both the direct and indirect effects of Internet use on young adults' pro-environmental attitudes and sustainable travel behavior, and the interactions between their attitudes and behavior.

Another important issue, which is often overlooked in research on millennials' mobility and ICT, is the effect of millennials' past ICT experience and changes in ICT usage over time on their current behavior. The theoretical underpinning for the reliance of behavior on past history can be conceptualized as hysteresis in behavior (28), which implies that current preferences are relative to a past history of behavioral choices (29). Inadequacy in research on such dynamic effects is largely attributed to the unavailability of data sources, as longitudinal analysis is required. Nevertheless, there are still a few studies that present some enlightening findings. Based on the Puget Sound Transportation Panel (PSTP) data, Kim and Goulias (30) modeled the relationships among time allocation to daily activities and travel, modal split, and changes in ICT ownership and availability between the years 1997 and 2000. They found that the effects of changes in ICT use depend on the location of the technology

used (home or workplace). For example, new computer users at work tend to spend more time on subsistence activities and less time on leisure, while new computer users at home generally spend more time on all activities and tend to use public transportation more often. In the context of millennial studies, Thulin and Vilhelmson (31) used the Swedish National Communication Survey data (1997–2001) to explore the impacts of young people's changing use of ICT on their in-home and out-of-home activity participation. The results revealed that increased computer use has no significant impact on young people's out-of-home activity engagement, but substantially displaces other in-home activities. In spite of these valuable discoveries, past studies have not considered the effects of past ICT experience and changing use of ICT over time on people's attitudes, which indirectly shape behavior. In addition, the period where the changes took place is short in these studies, and so they may not explain well the long-term effects of ICT use.

To fill the research gap identified above, this study applies structural equation modeling to explore both direct and indirect effects of Internet use, including past and current Internet usage, on young adults' environmental attitudes and travel choices. Their pro-environmental behavior is also modeled to get an overall assessment of the sustainability of millennials' lifestyles. Data used for this longitudinal study are from the 2004 British Household Panel Survey (BHPS) and the Understanding Society survey (2012/14, Wave 4) with samples of young teenagers and adults. The primary question this study attempts to answer is: How does past Internet usage, particularly in the early years, impact on young adults' environmental attitudes, travel choices and pro-environmental behavior? In order to get more insight into this question, two issues are also considered: a) effects of (current) Internet use on environmental attitudes, travel choices and pro-environmental behavior and b) the relationship between environmental attitude, and travel and pro-environmental behavior.

The remainder of this paper is organized as follows: a brief description of the data and variables used, followed by a discussion of the results, and finally a summary and conclusion.

DATA AND VARIABLES

This study is based on datasets from two nationwide longitudinal household surveys: the British Household Panel Survey (BHPS) and the Understanding Society survey. Started in 1991, the BHPS was carried out annually by the Institute for Social and Economic Research

(ISER) to understand the social and economic changes at both household and individual levels across the UK, following the same representative sample of individuals over a period of years. From Wave 19 (year of 2009), the BHPS became part of the new Understanding Society survey (from Wave 2 onwards), which contains a larger sample of households and individuals interviewed and more diverse topics. Each of the BHPS sample members is therefore issued a unique identifier within the Understanding Society datasets, which allows users to match BHPS data to Understanding Society Wave 2 data and onwards. As for the structure of the two surveys, they primarily consist of three questionnaires: a) household survey investigating households' composition and socioeconomic situations; b) individual survey understanding the socio-demographic status, behavior and attitudes (including Internet usage, travel choices, pro-environmental attitudes and behavior) of every adult (aged 16 and above) in selected households; and c) youth survey understanding the behavior and attitudes of young people (aged 10–15) (including their Internet usage) in households. For this study, young adults' past usage of the Internet needs to be linked to their current Internet-use habits, attitudes and behavior. Therefore, the youth sample contained in the youth survey of an early BHPS is firstly tracked in an individual survey dataset of a later Understanding Society survey according to the unique identifiers, thereby creating a comprehensive dataset containing information of each young person in both adolescence and adulthood. Considering their inclusion of key variables and appropriate time span, the 2004 BHPS and the 2012–14 (Wave 4) Understanding Society survey are selected as the data sources for the study. The initial sample size after data merging was 1,306.

As one of the key variables in this study, young people's Internet use was recorded in terms of frequency of accessing the Internet in both adolescence and adulthood. Respondents indicate their level of Internet use for personal use by placing themselves into one of the following bands: never use, less than once a month, at least once a month, at least once a week, and every day. Based on the usage frequency, they are further spilt into two groups of light Internet users and heavy Internet users in their two life stages. A heavy Internet user is defined as a person using the Internet every day, and a person without a daily-use habit is defined as a light Internet user. After removing all the cases with missing information on Internet use and behavior, the size of the sample was reduced to 792. In 2004, only 25.6% of the sampled youths were heavy Internet users; but in 2012–14, this figure had significantly

TABLE 1 Descriptive Statistics of Socio-Demographics and the Internet Use of Young Adults (N=792)

Variable Name	Descriptions	Mean	Min.	Max.
Socio-demographics				
sex	Male='0', female='1'	53.50%	0	1
age	age	20.47	18	24
kid0_4	Number of kids aged 0-4 in household	.11	0	2
kid5_15	Number of kids aged 5-15 in household	.28	0	4
adults	Number of adults in household	3.29	1	7
vehicles	Number of vehicles in household	1.76	0	3
income	Monthly household income (thousands of British Pounds)	3.39	.27	20.00
parent	Living with parents or not	77.17%	0	1
employed	Employment status: employed	37.34%	0	1
student	Employment status: student	49.59%	0	1
license	Holding driving license or not	50.61%	0	1
urban	Living in: rural area ('0'), urban area ('1')	71.78%	0	1
Internet usage				
interfreq1	Frequency of using the Internet: never use	0.49%	0	1
interfreq2	Use less than once/month	0.16%	0	1
interfreq3	Use at least once/month	3.42%	0	1
interfreq4	Use at least once/week	12.54%	0	1
interfreq5	Use every day (heavy users)	83.39%	0	1
Past and changing use of Internet				
stubborn	Stubborn light users	11.85%	0	1
new	New heavy users	61.52%	0	1
expered	Experienced heavy users	24.04%	0	1
past	Past heavy users	2.59%	0	1

increased to 83.4% for young adults. In order to reflect the changes in Internet use over time, indicator variables for four groups of persons were created based on past and current Internet-use habits:

- new heavy users: persons who were light Internet users in 2004 but are now heavy users (61.52%)
- past heavy users: persons who were heavy Internet users in 2004 but are now light users (2.59%)
- experienced heavy users: persons who were heavy Internet users in 2004 and still are (24.04%)
- stubborn light users: persons who were light Internet users in 2004 and still are (11.85%).

Effects of socio-demographics are also controlled in this study. Table 1 presents descriptive statistics of socio-demographic factors. The ages of the sampled young adults range from 18 to 24, and most of them (77%) live with their parents, which is not surprising given the low ratio of employment (37%) and that nearly 50% are students. Half of them hold a valid driving license, and most (72%) live in urban areas. Table 1 also displays indicator variables of Internet use and changes in use.

In terms of young adults' attitudes and behavior, which are considered as the endogenous variables in the model for study, these were recorded as a set of ordinal variables in the dataset. People's travel choice behavior was represented by the frequencies of traveling by car, bus, train and bike, from 'less than once a year' to 'at least once a day'. Frequency of car sharing was measured on a scale from 'never' to 'always'. The same frequency scale was applied to describe young adults' pro-environmental behavior, from 'never' to 'always'. Notably, water use was represented by frequency of water wasting, which means the scale from 'never' to 'always' implies a less and less pro-environmental pattern. As for environmental attitudes, attitudinal variables in the dataset were selected, and an attitude scale used to measure each of them. See Table 2.

According to Table 2, it is clear that private cars/vans are still the most popular travel mode for young adults, with around 55% of the sample travelling by them on a daily basis. In contrast, cycling is the least popular mode choice with over 62% of young persons using it less than once a year. In terms of environmental behavior, the young adults generally do well

1 **TABLE 2 Distributions of Behavioral and Attitudinal Variables Used (N=792)**

Categories	Variable Name/Description	Frequency or Attitude Scales (% of total sample)				
Travel Choices		Less than once/year	At least once/year	At least once/month	At least once/week	At least once/day
	car/Frequency of travelling by private car/van	2.2%	2.9%	9.0%	31.0%	54.9%
	bus/Frequency of travelling by bus	27.9%	15.7%	19.6%	23.8%	13.0%
	train/Frequency of travelling by train	25.8%	32.2%	26.5%	10.2%	5.3%
	cycling/Frequency of travelling by bike	62.2%	15.5%	7.9%	9.3%	5.1%
		Never	Not very often	Quite often	Very often	Always
	shared/Frequency of travelling by car sharing	52.7%	10.2%	18.2%	11.8%	7.1%
Environmental Behavior	light/Switching off lights	2.5%	7.5%	14.3%	23.9%	51.9%
	water/Keep the tap running while you brush your teeth	39.0%	19.9%	16.8%	13.3%	11.1%
	heating/Put more clothes on when you feel cold rather than relying on heating	12.7%	12.4%	20.0%	28.4%	26.5%
	recycled/Buy recycled paper products	47.0%	22.3%	17.1%	8.1%	5.5%
	bag/Take your own shopping bag when shopping	40.2%	14.1%	12.0%	13.1%	20.5%
Attitudes & Perceptions		Happy with what I do		Like to do bit more	Like to do lots more	
	feellife/How feel about current lifestyle and the environment	49.5%		32.3%	18.2%	
		Do nothing env friendly	1/2 things env friendly	Few things env friendly	Mostly env friendly	Everything env friendly
	lifeenvir/Current lifestyle environmentally friendly	10.7%	43.6%	31.7%	10.5%	3.5%
		Disagree strongly	Tend to disagree	Neither agree nor disagree	Tend to agree	Agree strongly
	beingreen/Being green is an alternative lifestyle for the majority	5.0%	25.8% (Disagree)		53.3% (Agree)	15.9%
	behavclim/Behavior contributes to climate change	3.3%	8.6%	22.3%	46.7%	19.1%
	envirprod/Pay more for environmentally friendly products	4.1%	8.9%	27.6%	43.2%	16.2%
	changenvir/Help environment with changes fitting with lifestyle	3.2%	9.1%	26.4%	45.4%	15.9%

2

in rational use of resources, as most of them consume energy (electricity, water and gas) conservatively. However, their purchasing behavior seems to be less environmentally friendly, since almost half never buy recycled paper products or take their own bags when shopping, despite generally showing positive attitudes towards environmental protection and 'going green' In particular, they seem to be open to changing their behavior in order to improve the environment, as most of them 'tend to agree' or 'agree strongly' with the change.

METHOD AND MODEL

We applied structural equation modeling (SEM) to reveal the complex interactions among Internet use, environmental attitudes, travel choices and pro-environmental behavior. The strength of SEM is its capability to simultaneously estimate causal relationships among a set of latent and observed variables based on a specified model (32). Our context certainly involved multiple relationships. For example, we could hypothesize that attitudes affect both travel choices and pro-environmental behavior and in turn are affected by them, and that choices and behavior each affect the other. Moreover, apart from the direct effect of one variable on another, SEM is also able to detect the indirect effects between two variables as mediated by other intervening variables. The total effect therefore consists of a direct effect and one or more indirect effects. Such a technique is most needed by our study as we seek to explore the mediating effects of environmental attitudes on the relationships between Internet use and behavior. A traditional SEM analysis consists of two parts: a measurement model and a structural model. The measurement model specifies how latent variables are explained by the observed variables, while the structural model specifies the relationships among latent variables and captures the regression effects of exogenous (independent) variables on endogenous (dependent) variables, and the effects of endogenous variables on each other.

Based on the techniques of SEM and data and variables used, we developed a modeling framework for this study. As shown in Figure 1, young adults' socio-demographics, current usage of the Internet (frequency of use) and changes in Internet-use habits were treated as exogenous variables. For changes in Internet usage, three indicator variables, new, experienced and past heavy Internet users, were included, with one indicator of stubborn light users referenced and omitted. The remaining attitudinal and behavioral variables were considered as endogenous variables. To simplify the model structure and to clearly represent the attitude-related relationships, a latent variable of positive attitude towards environment

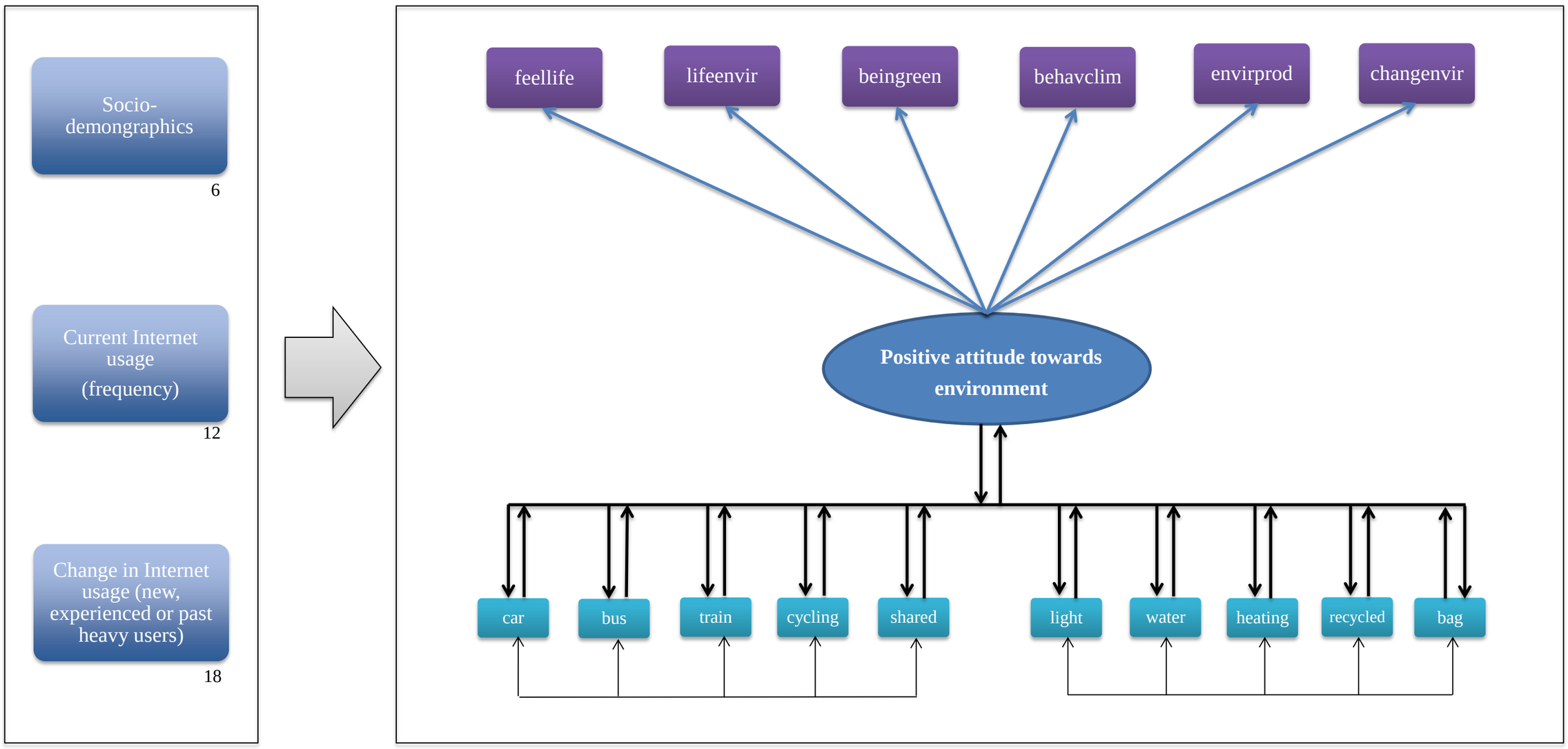

FIGURE 1 Modeling Framework

was created based on the six observed attitudinal variables in the dataset. In addition to the effects of attitude on travel and pro-environmental behavior, the potential effects of behavior on attitude in turn were also considered in the model, as some behavioral theories, such as the self-perception theory, imply that behavior may shape and precede attitudes (33). Moreover, correlations among travel choices and among pro-environmental behavior were modeled. The model was run in the Mplus environment. As for the estimation method of SEM, we used the WLSMV (weighted least squares means and variance adjusted) estimator as all the dependent variables modeled were ordered categorical variables with non-normal distribution.

A variety of fit indices have been developed to assess the goodness of fit of a structural equation model. Mplus usually provides the following indices:

• **Chi-square (χ^2):** traditional measure for evaluating overall model fit by assessing the 'magnitude of discrepancy between the sample and fitted covariance matrices' (34). A smaller value generally implies a better model, and a good model fit would provide an insignificant result at a 0.05 threshold. However, this measure is problematic for large sample sizes and deviations from multivariate normality assumptions. The relative/normed chi-square (χ^2/d.f.) is developed to minimize the impact of sample size with a value of less than 5 implying an acceptable level (35).

• **Tucker–Lewis index (TLI):** also known as the non-normed fit index (NNFI), analyzes the discrepancy between the chi-squared value of the hypothesized model and that of the null model with a penalty for adding parameters. Values over 0.90 or over 0.95 are generally considered acceptable (36).

• **Comparative fit index (CFI):** represents the ratio between the discrepancy of target model to the discrepancy of the independence model. Values closer to 1 generally indicate acceptable fit.

• **Root mean square error of approximation (RMSEA):** measures the population discrepancy per degree of freedom to compensate for the effects of model complexity. Values less than 0.05 indicate a good fit, and values as high as 0.08 represent a reasonable fit (37).

• **Standardized/weighted root mean square residual (SRMR/WRMR):** square root of (weighted) discrepancy between the residuals of the sample covariance matrix and the hypothesized covariance model. Values less than 0.08 can be considered as a good fit (34). For WRMR, values less than 1.0 are generally acceptable (38).

RESULTS

The goodness-of-fit indices presented in Table 3 show that the model performs reasonably well. Although the chi-square is significant at 324.461, other indices indicate a good fit. Table 3 also shows the standardized parameter estimates of six observed attitudinal indicators used for constructing the latent variable. All the observed variables can be significantly explained by the factor of positive attitude towards environment with positive correlations. People with a positive attitude towards the environment are more likely to feel environmentally friendly about their current lifestyles, and more willing to change their behavior or lifestyle if this would improve the environment.

TABLE 3 Parameter Estimates of Factor Analysis and Model Goodness-of–fit Indices (N=792)

Factor	Observed Variables	Standardized Parameter Estimate
Positive Attitude towards Environment	feellife	.132**
	lifeenvir	.404**
	beingreen	.265**
	behavclim	.063**
	envirprod	.166**
	changenvir	.344**
Goodness-of–fit Indices	Chi-square=324.461 (d.f. =161, p-value=.000) Chi-square/d.f =2.015 TLI=0.912 CFI=0.930 RMSEA=0.042, Pro.(RMSEA<=.05)=0.974 WRMR=0.092	

(Note: ** Significant at the 5% level.)

Tables 4 and 5 show the results of causal influences of exogenous variables on endogenous variables and that of endogenous variables upon one another. Table 4 presents

TABLE 4 Standardized Effects and Correlations among Endogenous Variables (N=792)

	Attitude (as resulting variable)	car	bus	train	cycling	shared	light	water	heating	recycled	bag
Attitude (as causal variable)	n.a.	-.291**	.254**	.217**	.103**	.073	.139*	-.336**	.731**	.398**	.141*
car	-.287**	n.a.	-.233**	-.066*	-.112**	.116	n.a.	n.a.	n.a.	n.a.	n.a.
bus	.033	-.233**	n.a.	.165**	.041	.004*	n.a.	n.a.	n.a.	n.a.	n.a.
train	.051	-.066*	.165**	n.a.	.068**	.010	n.a.	n.a.	n.a.	n.a.	n.a.
cycling	.076**	-.112**	.041	.068**	n.a.	.001	n.a.	n.a.	n.a.	n.a.	n.a.
shared	.049	.116	.004*	.010	.001	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
light	.219	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-.125**	.106**	.036	.017
water	-.377	n.a.	n.a.	n.a.	n.a.	n.a.	-.125**	n.a.	-.114**	-.057*	-.006
heating	.340	n.a.	n.a.	n.a.	n.a.	n.a.	.106**	-.114**	n.a.	.102*	.031
recycled	.057**	n.a.	n.a.	n.a.	n.a.	n.a.	.036	-.057*	.102*	n.a.	.108**
bag	.018	n.a.	n.a.	n.a.	n.a.	n.a.	.017	-.006	.031	.108**	n.a.

(Note: n.a. = not applicable; *Significant at the 10% level; ** Significant at the 5% level)

the interactions among endogenous variables. In general, the attitude construct (namely, positive attitude towards environment) positively influences young adults' sustainable travel choices including less frequent car use and more frequent use of public transportation and bicycles. In addition, pro-environmental behavior (e.g. energy saving and eco-friendly purchasing) is also positively affected by attitude. In terms of the effects of behavior on attitude, although travel choices and pro-environmental behavior are not generally found to shape environmental attitude, less car use, more cycling and more frequent purchasing of recycled products significantly contribute to people's positive attitude towards the environment. As for the interactions among different travel choices, car use is negatively correlated to taking public transport and cycling. Traveling by train is positively correlated to travelling by bus and cycling. In addition, most pro-environmental behavior is positively related to each other, except for water use which is negatively correlated with other behavior as it is measured by frequency of water wasting.

Table 5 presents both the direct and total effects of exogenous variables on endogenous behavioral variables and attitudinal construct in the model. Results and findings are elaborated as follows.

Effects of Socio-Demographics

Most of the socio-demographic characteristics show significant correlations with travel choices, pro-environmental behavior and attitude. For instance, compared with males, young females tend to use cars less, take public transport more often and to be more environmentally friendly in general. They also have more positive environmental attitudes. Young people from the households with more adults travel by car less frequently, and travel by bus and rideshare more often. The reason could be the increased car sharing among household members. In contrast, people from households with more vehicles tend to use cars more frequently, and use other travel modes less. As well, they have less positive attitudes towards the environment. Higher household income generally brings about more physical travel for young people, both by car and public transport. Compared with the people living by themselves, those living with their parents tend to travel by car less, and take the bus or rideshare more often. They are also less likely to save energy or to have an environmentally friendly attitude. It seems that their behavior and attitude is influenced by parental involvement in their lives. Both employers and students travel more frequently than

TABLE 5 Standardised Direct and Total Effects of Exogenous Variables on Endogenous Variables (N=792)

Exogenous Variables		Endogenous Variables										
		Travel Choice					Pro-environmental Behaviour					Positive Attitude
		car	bus	train	cycling	shared	light	water	heating	recycled	bag	
Socio-demographics												
sex	direct	-.145**	.056**	.010*	–	–	.114*	-.215**	.072*	.259**	.332**	.017*
	total	-.147**	.068**	.015*	–	–	.136*	-.216*	.033	.241**	.321**	.021*
age	direct	.057**	-.108**	–	–	–	–	–	–	–	–	–
	total	.051**	-.104*	–	–	–	–	–	–	–	–	–
kid0_4	direct	–	–	-.136**	–	–	–	–	-.185**	-.167**	-.273**	–
	total	–	–	-.139**	–	–	–	–	-.550**	-.333**	-.286**	–
kid5_15	direct	–	–	–	–	–	–	–	–	–	–	–
	total	–	–	–	–	–	–	–	–	–	–	–
adults	direct	-.128**	.185**	–	–	.113*	–	–	–	–	–	–
	total	-.133**	.189**	–	–	.117**	–	–	–	–	–	–
vehicles	direct	.421**	-.585**	-.136*	-.093**	-.161**	-.117*	–	–	–	–	-.007*
	total	.431**	-.594**	-.165*	-.106**	-.158**	-.122**	–	–	–	–	-.171**
income	direct	.376**	.113**	.063**	.007	–	-.008**	.027*	-.126**	–	–	.011*
	total	.397**	.119**	.081**	.015*	–	-.005*	.039*	-.157**	–	–	.013
parent	direct	-.164**	.231*	–	–	.322**	-.291**	.056**	-.271**	–	-.015**	-.094**
	total	-.272**	.234**	–	–	.344**	-.291**	.053**	-.381**	–	-.013*	-.091*
employed	direct	.217**	.186*	.186*	.306*	–	-.124*	–	–	–	–	–
	total	.206**	.191**	.228*	.301*	–	-.154*	–	–	–	–	–
student	direct	–	.038*	.419**	.207**	.123*	-.229*	.124	–	–	–	.617**
	total	–	.080**	.550**	.231**	.128**	-.206*	-.053*	–	–	–	.551**
licence	direct	.319**	-.216**	-.039*	–	-.146**	–	–	–	–	–	–
	total	.297**	-.205**	-.017*	–	-.135**	–	–	–	–	–	–
urban	direct	-.138*	–	-.112**	.060*	–	–	-.211*	–	–	–	.050**
	total	-.155**	–	-.119**	.077**	–	–	-.252*	–	–	–	.202**
Internet Use												
interfreq2	direct	–	–	.047	–	–	–	–	–	–	–	–
	total	–	–	.052*	–	–	–	–	–	–	–	–
interfreq3	direct	–	.362**	.271*	–	–	.019	-.014	-.008	–	–	.227*
	total	–	.372**	.283**	–	–	.256*	-.322*	.168**	–	–	.257**
interfreq4	direct	-.306*	.774**	.729**	-.236**	–	.101*	.009	.035	.076*	.104**	.275**
	total	-.319**	.777**	.749**	-.231**	–	.470**	-.366**	.283**	.518**	.607**	.289**
interfreq5	direct	-.672**	.900**	.944**	-.238**	.086*	.134	-.004**	.005*	.012	.112	.405**
	total	-.697**	.874**	.913**	-.249**	.082**	.585**	-.614**	.428**	.576**	.585**	.623**
Past and changing use of Internet												
new	direct	–	.067**	.103*	–	.126*	.024	–	-.004	–	–	.335*
	total	–	.069**	.110*	–	.129*	.257*	–	.082*	–	–	.369*
expered	direct	-.102*	.192**	.165*	.073*	.134*	.056	-.012	–	.052**	.023*	.606**
	total	-.228**	.365**	.345**	.181*	.248*	.393**	-.272*	–	.490**	.358*	.517**
past	direct	–	–	–	–	–	.005*	–	.014	–	–	–
	total	–	–	–	–	–	.007	–	.008*	–	–	–

(Note: dash (–) = no significant direct or total effect detected; *Significant at the 10% level; ** Significant at the 5% level)

unemployed people do. While employed people tend to use the car more often, students are more likely to rideshare. Moreover, students show more positive attitudes towards the environment. Possession of a driving license is positively related to frequent car use, but negatively related to use of other modes. Compared with those living in rural areas, urban dwellers tend to use the car and take trains less, but cycle more often.

Effects of Internet Use

Young adults' Internet-use habits have significant impacts on their travel choices, pro-environmental behavior and attitude. In general, people with high usage of the Internet tend to travel by car and by bike less frequently, and take public transportation more often. The negative effects of Internet use on car use and cycling are only detected for medium to heavy Internet users who are likely to substitute physical activities for virtual ones, thereby reducing travel. On the other hand, frequent Internet users may have more access to (and more reliance on) technology-enabled transportation services in public transport systems, such as real-time bus information and on-board Wi-Fi. Therefore, they are more likely to choose bus and train as travel modes. Additionally, heavy Internet users tend to rideshare more often compared with light users. Access to smart technologies such as car-sharing apps could explain this. Moreover, the frequent Internet users also tend to exhibit more environmentally friendly behavior and have a positive attitude to the environment. Notably, in the causal relationship between Internet use and pro-environmental behavior, the indirect effects of Internet usage, which are channeled through attitude construct, account for most of the total effects. In other words, use of the Internet influences young adults' pro-environmental behavior via its impact on their attitude to the environment. As suggested by the literature review, the Internet can cultivate and shape people's pro-environmental attitudes and awareness, thereby influencing their behavior.

Longitudinal Effects of Internet Use

Young adults' travel choices and pro-environmental behavior and attitude are also related to their past Internet-use habits and changes in use. Compared with the stubborn light users who have never used the Internet on a daily basis, new heavy users, who recently started to use the Internet every day, tend to take public transport and rideshare more often. As mentioned

before, such influences may be ascribed to access to technologies. Same Internet-induced impacts on travel choices can also be found for experienced heavy users who have been using the Internet daily since they were teenagers. However, experienced heavy users tend to have more sustainable travel patterns, as they also use the car less and cycle more often. As for the past heavy users who dropped the habit of using the Internet daily, no significant distinction is detected between their travel behavior and that of stubborn light users, since they both have low access to technologies in their current life. Attention therefore needs to be paid to experienced heavy users and the distinctions between new and experienced heavy users. Similar to the relationship between Internet use and pro-environmental behavior, the total effects of keeping daily Internet usage on young adults' travel patterns are largely explained by the indirect effects mediated by environmental attitude. This result is underpinned by the fact that such habit-keeping has a positive impact on the environmental attitude construct, which is more significant with a larger regression coefficient compared with the effect caused by starting a habit of heavy use. Different from new heavy users, experienced heavy users have been exposed to the Internet since adolescence. The long-term exposure to the Internet starting from an early age would play an important role in their attitude and lifestyle formation, including their attitudes towards the environment (26,39). As the literature suggests, the Internet generally encourages and promotes environmentalism through various approaches (21–26). Thus, intensive exposure to the Internet in the long term profoundly shapes young people's attitudes towards the environment, thereby directing behavior and choices towards more sustainable patterns. Such long-term effects on environmental attitude also significantly mediate the relationship between consistent heavy use of the Internet and pro-environmental behavior. The result shows that experienced heavy users generally have more sustainable lifestyles (saving energy and eco-friendly shopping) compared with other user groups.

SUMMARY AND CONCLUSIONS

This study demonstrated the use of longitudinal analysis to examine both the direct and indirect effects of current and past Internet usage on young adults' travel choices, and pro-environmental attitude and behavior. The focus is on the intermediary role attitude plays in Internet-induced effects on choices and behavior, and how young people's past habits of using the Internet, and changes in usage, impact on their travel and pro-environmental

behavior. The analysis draws on the British Household Panel Survey (BHPS) and the Understanding Society survey, which provide uniquely suited datasets recording individuals' behavior, attitudes and lifestyles in their different age stages. By merging the data of both surveys, a comprehensive dataset is created containing information about young people in both adolescence and adulthood. Aside from the multiple socio-demographic, attitudinal and behavioral variables considered, a set of 'experience' variables was created to represent young people's past and changing usage of the Internet.

Structural equation modeling (SEM) was applied to explore the complex relationships among variables. A latent variable – positive attitude to the environment – was constructed first, based on six observed attitudinal variables in the dataset. Such a construct is found to positively affect young adults' sustainable travel choices including less car use and more frequent use of public transport and cycling, and their pro-environmental behavior (energy saving and eco-friendly purchasing). Although environmental attitude is not generally shaped by choices and behavior, it is significantly influenced by Internet usage. Young adults with high-frequency Internet use tend to have a more positive attitude towards the environment, and also behave in a more environmentally friendly way. By changing activity/travel patterns and providing more access to technologies, heavy Internet usage leads to a more sustainable mobility paradigm with reduction in car use and increase in public transport and rideshare. In addition, pro-environmental behavior can be expected if young adults use the Internet frequently. However, the direct Internet-induced effects on pro-environment behavior are not dominant. The indirect effects mediated by environmental attitude play a significant role in the Internet–behavior relationship instead. The intermediary role played by attitude can also be detected in the effects of consistent heavy Internet use on young adults' choices and behavior. More specifically, young people who keep the habit of using the Internet daily (defined as experienced heavy users in this study) get exposed to the long-term effects of the Internet, which may shape their environmental attitudes and awareness more profoundly. Such attitude formation characterizes their behavior, which may be distinct from other young people's behavior. Although the new heavy users, who started the daily Internet habit later, tend to frequently use public transport and rideshare, such Internet-induced effects are largely enabled by more access to technologies. For experienced heavy users, however, their pro-environmental attitude, which is shaped by their long-term exposure to the Internet, greatly contributes to the total Internet-induced impacts on their choices and behavior by

acting as a mediator. As a result, they have more sustainable travel patterns even with less car use and more cycling, and a more environmentally friendly lifestyle.

Improvements for this study could be made by considering the changes in socio-demographics over time, such as changes in household composition, household income, vehicle availability and employment status, in the model, as they may also influence people's travel choices and behavior from a longitudinal perspective.

REFERENCES

1. Delbosc, A., and G. Currie. Causes of youth licensing decline: A synthesis of evidence. Transport Reviews, Vol. 33, No. 3, 2013, pp. 271–290.
2. Dutzik, T, J. Inglis, and P. Baxandall. Millennials in Motion: Changing Travel Habits of Young Americans and the Implications for Public Policy. U.S. PIRG Education Fund, 2014.
3. Thakuriah, P., S. Menchu, and L. Tang. Car Ownership Among Young Adults: Generational and Period-Specific Perspective. In Transportation Research Record: Journal of the Transportation Research Board, No. 2156, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 1–8.
4. Frändberg, L., and B. Vilhelmson. Spatial, generational and gendered trends and trend-breaks in mobility. In (Eds.), Handbook of sustainable travel (T. Gärling, D. Ettema, and M. Friman, eds.). Springer, Dordrecht, 2013, pp. 15-32.
5. McDonald, N.C. Are Millennials Really the "Go-Nowhere" Generation? Journal of the American Planning Association, Vol. 81, No. 2, 2015, pp. 90-103.
6. Kuhnimhof, T., J. Armoogum, R. Buehler, J. Dargay, J. M. Denstadli, and T. Yamamoto. Men shape a downward trend in car use among young adults—Evidence from six industrialized countries. Transport Reviews, Vol. 32, No. 6, 2012, pp. 761–779.
7. Blumenberg, E., B. D. Taylor, M. Smart, K. Ralph, M. Wander, and S. Brumbagh. *What's Youth Got to Do with It? Exploring the* Travel Behavior of Teens and Young Adults. UCTC-FR-2012-14, University of California Transportation Center, 2012.
8. Garikapati, V. M., R. M. Pendyala, E. A. Morris, P. L. Mokhtarian, and N. McDonald. Activity patterns, time use, and travel of millennials: a generation in transition? Transport Reviews, Vol, 36, No. 5, 2016, pp. 558-584.
9. Polzin, S. E., X. Chu, and J. Godfrey. The impact of millennials' travel behavior on future personal vehicle travel. Energy Strategy Reviews, Vol. 5, 2014, pp. 59–65.
10. Thakuriah, P., and G. Geers. Transportation and Information: Trends in Technology and Policy. Springer, N.Y., 2013.
11. Lyons, G. Transport's digital age transition. Journal of Transportation and Land Use, Vol. 8, No. 2, 2015, pp. 1–19.
12. Thakuriah, P., and Y. Mallon-Keita. An analysis of household transportation spending during the 2007-2009 US economic recession. Presented at the 93rd

Annual Meeting of the Transportation Research Board, Washington D.C., 2014.
13. Allstate. *Economy Puts the Brakes on Parents' Spending for Teen Cars, Driving* Expenses, September 2011.www.allstatenewsroom.com/news/economy-puts-the-brakes-on-parents-spending-for-teen-cars-driving-expenses/. Accessed Jul. 27, 2016.
14. Dutzik, T, T. Madsen, and P. Baxandall. A New Way to Go: The Transportation Apps and Vehicle-Sharing Tools that Are Giving More Americans the Freedom to Drive Less. U.S. PIRG Education Fund, 2013.
15. Martin, E., S. A. Shaheen, and J. Lidicker. Impact of Carsharing on Household Vehicle Holdings Results from North American Shared-Use Vehicle Survey. In Transportation Research Record: Journal of the Transportation Research Board, No. 2143, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 150-158.
16. Circella, G., L. Fulton, F. Alemi, R. M. Berliner, K. Tiedeman, P. L. Mokhtarian, and S. Handy. *What Affects Millennials' Mobility?* PART I: Investigating the Environmental Concerns, Lifestyles, Mobility-Related Attitudes and Adoption of Technology of Young Adults in California. National Center for Sustainable Transportation, 2016.
17. van Wee, B. Peak car: The first signs of a shift towards ICT-based activities replacing travel? A discussion paper. Transport Policy, Vol. 42, 2015, pp. 1-3.
18. Sakaria, N. and N. Stehfest. Millennials & Mobility: Understanding the Millennial Mindset and New Opportunities for Transit Providers. Transportation Research Board of the National Academics, 2013.
19. Gehlert, T., K. Dziekan, and T. Gärling. Psychology of sustainable travel behavior. Transportation Research Part A, Vol. 48, 2013, pp.19-24.
20. Adjei, E. and Behrens, R. Travel Behaviour Change Theories and Experiments: A Review and Synthesis. Presented at the 31st Southern African Transport Conference, Pretoria, South Africa, 2012.
21. Good, J. Internet use and environmental attitudes: A social capital approach. In S. P. Depoe (ed.) The Environmental Communication Yearbook, Vol. 3 (S. P. Depoe, ed.), Taylor and Francis, New Jersey, 2006, pp. 195-216.
22. Nistor, L. The role of the Internet in shaping environmental concern. A focus on post-communist Europe. Journal of Comparative Research in Anthropology and

Sociology, Vol. 1, No. 2, 2010, pp. 145-167.

23. Stokols, D., and M. Montero. Toward and environmental psychology of the Internet. In Handbook of Environmental Psychology (R. B. Bechtel, and A. Churchman, eds.), John Wiley and Sons, N. Y., 2002, pp. 661-675.
24. Pickerill, J. Cyberprotest. Environemntal Activism Online. Massachusetts University Press, N. Y., 2003
25. Zelwietro, J. The politicization of environmental organizations through the Internet. The Information Society, Vol. 14, 1998, pp. 45-56.
26. Allen, M., R. H. Wicks, and S. Schulte. (2013) Online Environmental Engagement Among Youth: Influence of Parents, Attitudes and Demographics. Mass Communication and Society, Vol. 16, No. 5, 2013, pp. 661-686.
27. Fogg, B.J. (2003). Persuasive technology: Using computers to change what we think and do. Morgan-Kaufmann, San Francisco, 2003.
28. Georgescu-Roegen, N. The Entropy Law and the Economic Process. Harvard University Press, Cambridge, 1971.
29. Elster, J. A Note on Hysteresis in the Social Sciences. Synthese, Vol. 33, 1976, pp. 371-391.
30. Kim, T.-G., and K. G. Goulias. Cross sectional and longitudinal relationships among information and telecommunication technologies, daily time allocation to activity and travel, and modal split using structural equation modeling. Presented at 83rd Annual Meeting of the Transportation Research Board, Washington, D.C., 2004.
31. Thulin, E., and B. Vilhelmson. Virtual mobility and processes of displacement: Young people's changing use of ICT, time, and place. Networks and Communication Studies, Vol. 20, 2006, pp. 27-39.
32. Kaplan, D. Structural Equation Modeling: Foundations and Extensions. Sage, London, 2000.
33. Bem, D. J. Self-perception Theory. In Advances in Experimental Social Psychology (L. Berkowitz, ed.), Academic Press, N. Y., 1972.
34. Hu, L.T., and P. M. Bentler. Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. Structural Equation Modeling, Vol. 6, No. 1, 1999, pp. 1-55.
35. Wheaton, B., B. Muthen, D. F. Alwin, and G. Summers. Assessing Reliability and Stability in Panel Models. Sociological Methodology, Vol. 8, No. 1, 1977, pp. 84-136.

36. Hu, L. T., and P. M. Bentler. Evaluating model fit. In Structural equation modeling: Concepts, issues, and applications (R. H. Hoyle, ed.), Sage, Thousand Oaks, CA, 1995, pp. 76-99.
37. Browne, M. W., and R. Cudeck. Alternative ways of assessing model fit. In Testing structural equation models (K. A. Bollen, and J. S. Long, eds.), Sage, Newsbury Park, CA, 1993, pp. 136-162.
38. Yu, C.-Y. Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes. Doctoral dissertation, University of California, Los Angeles, 2002.
39. McMillan, S.J., and M. Morrison. Coming of age with the Internet: A qualitative exploration of how the internet has become an integral part of young people's lives. New Media & Society, Vol, 8, No. 1, 2006, pp. 73-95.