Discovering Causal Structure from Attitudinal Data: What Motives People to Use Mobility-Management Travel Apps

Aliasghar Mehdizadeh Dastjerdi *[a], Stephane Hess [b], Francisco Camara Pereira [c]

[a] *Department of Management Engineering, Technical University of Denmark, Bygningstorvet 116B, 2800 Kgs. Lyngby, Denmark, email: meghdad@dtu.dk*
[b] *Institute for Transport Studies and Choice Modelling Centre, 34-40 University Road, University of Leeds, Leeds LS2 9JT, United Kingdom, email: s.hess@leeds.ac.uk*
[c] *Department of Management Engineering, Technical University of Denmark, Bygningstorvet 116B, 2800 Kgs. Lyngby, Denmark, email: camara@dtu.dk*

ABSTRACT

In recent years, one of the solutions that has received much attention with a view to motivating change toward sustainable urban mobility is information dissemination and persuasion delivered through mobility-management travel apps. However, their influence to promote sustainability highly depends on understanding the underlying mechanisms and processes of behavior change. This paper aims to uncover causal structure in travel app users' behavior, in connection with behavioral theories. This study investigates the applicability of causal discovery methods to establish the associations between the constructs of a theoretical framework. The case-study focuses on the new travel information system in Copenhagen (Denmark). 822 Danish citizens participated in a technology-use preference survey distributed online. The results show the capability of the Max-Min Hill-Climbing (MMHC) algorithm to learn the causal structure of a theoretical framework, and accordingly interpret established associations. The proposed decision framework incorporates Alderfer's ERG theory of human needs and Bandura's triadic reciprocal determinism to explain the adoption intention of mobility-management travel apps.

Keywords: Travel app; behavior change; travel information; causal discovery

1. Introduction

Transport activity has a wide range of negative effects including congestion, air pollution, CO2 emissions and accidents. Furthermore, the increasing complexity and demand of transport services strain transportation systems, especially in urban settings with limited possibilities for building new infrastructure. Such transport-related issues have urged the need to encourage sustainable urban mobility. One of the proposed solutions to induce such change is mobility-management travel apps. This paper describes a study of the intention to use a real-time multi-modal travel app aimed at motivating travel behavior change in Copenhagen (Denmark). The proposed app, which is not yet operational, includes both multi-modal travel information and persuasive strategies. The underpinning concept is based on the Fogg's framework (*1*, *2*) in which system design is persuasive and explicitly attempts "to change attitudes or behaviors or both (without using coercion or deception)". This is achieved by raising awareness of individual choices, patterns, and the consequences of activities. Persuasive technologies monitor human activities in relation to resource usage, and provide information to the user for the purpose of motivating behavioral change. Social motivators are also offered to influence the user's attitude and behavior. Regarding the persuasive features, the travel app is supposed to provide the users with information about CO2 emissions produced/saved by taking different travel options and the amount of calories burnt by taking active modes. Moreover, the app enables its users to register for an environmentally-friendly loyalty program: the more environmentally-friendly an itinerary they take, the more bonus points they earn. The bonus points can be used to obtain some free services (through vouchers) or public transport tickets. The collected bonus points and travel information, i.e. CO2 emissions saved and calories burnt, could be shared on social media.

Empirical studies provide evidence that these new features are important in influencing users to change their travel behavior (*3*–*6*). However, the prospective for mobility-management travel apps to stimulate sustainable mobility rests not only on the original and proper employment of the behavior change strategies, but also on "explicitly grounding it on established theoretical constructs from behavioral theories". The theoretical foundation is important because it positively and significantly influences the effectiveness of the system (*7*–*9*). As noted by Sunio and Schmöcker (*10*), there is a gap in current knowledge regarding the study of mobility-management travel apps with support in behavioral theories, which should be explored further. This study addresses this gap by means of a social cognitive theory-based examination. However, compared to conventional methods in technology adoption research, this study adopts a reverse approach in which the associations between theoretical constructs are explored by a causal discovery method.

Some well-acknowledged methods from machine learning to discover causality rest on probabilistic graphical modeling (PGM) (*11*, *12*). The structure of PGMs is a directed acyclic graph (DAG), with its nodes representing random variables and edges indicating dependence relationships between variables (*13*). There are two main approaches for learning the causal structure, namely constraint-based techniques and score-based techniques. The constraint-based approach (*12*, *14*, *15*) uses conditional independence tests to learn the dependence structure of the data. In this context, the PC algorithm (*16*) is the most commonly used. The PC algorithm has two stages. It starts with a complete, undirected graph and removes recursively edges as conditional relations are identified, i.e. the skeleton establishment. Then, it determines the orientation to form an equivalence class of DAGs. It is important to note that DAGs that induce the same sets of conditional independence relations are called Markov equivalent. The score-based algorithms (*11*) search for all possible DAGs while using a scoring function to measure the fit of each DAG to the data. The DAG that best fits the data will be chosen. Some well-known search methods such as hill-climbing algorithm or greedy search are applied to optimize a score, for example the BIC or the AIC. Tsamardinos et al. (*17*) presented a hybrid constraint/score-based algorithm called Max-Min Hill-Climbing (MMHC) for discovering causal structure. The algorithm combines the ideas of both approaches. It starts with a constraint-based algorithm to find the skeleton and then performs a greedy hill-climbing search to orient the edges. The present study investigates the applicability of the MMHC algorithm to establish the associations between the constructs of a theoretical framework for the study of intention to use the new mobility-management travel app in Copenhagen.

2. Theoretical framework

This study employs Bandura's triadic reciprocal determinism (TRD) to explain user adoption behavior with respect to the new travel app. TRD is often used as a conceptual/theoretical framework in studies using social cognitive theory (SCT) for understanding, predicting and changing behavior. TRD represents human behavior as a result of the interaction between personal/cognitive factors, behavior and the environment. Therefore, human behavior could be a depiction of the cognition of themselves and the environment around them (*18*, *19*). Figure 1 displays the model of triadic reciprocal determinism.

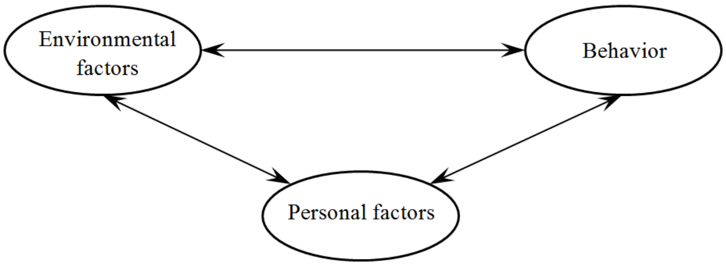

Figure 1. Bandura's Triadic Reciprocal Determinism

Zhu et al. (*20*) conceptualized a behavioral model, based on TRD, to investigate the factors influencing the use of ridesharing mobile apps. In their proposed framework, personal factors and the environment were presented by technology self-efficacy and perceived value, respectively. Figure 2 shows the proposed conceptual model in which the solid and dotted lines denote, respectively, before-adoption and post-adoption.

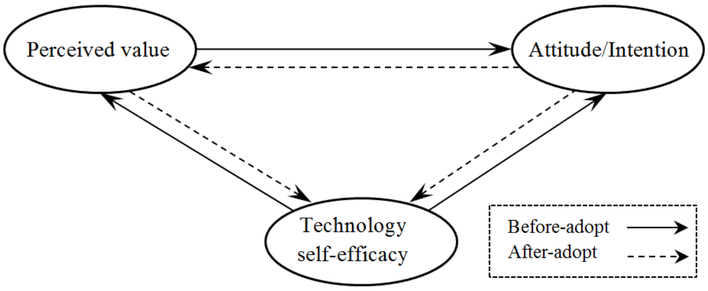

Figure 2. Self-efficacy based value adoption model

Previous empirical studies showed the importance of functional (i.e., monetary, performance and convenience motives), hedonic (i.e., social acceptance and enjoyment) and normative values to adopt sustainable innovations such as electric vehicles (*21*), alternative fuel vehicles (*22*, *23*) and green IT (*24*, *25*). In the context of mobile information technologies, Zhu et al. (*20*) investigated important factors that influence adoption of ridesharing apps. They showed that functional motives (e.g., time and monetary savings) together with hedonic motives (e.g., enjoyment and social image improvement) significantly influence the overall perceived value of ridesharing apps. Functional and hedonic motives were also identified by recent studies as important antecedents of the intention to adopt mobile devices such as mobile apps for booking/shopping purposes (*26*–*28*), mobile social networking services (*29*, *30*) and smartwatches (*31*, *32*). While simple navigation apps are mostly driven by their functional value, the use of mobility-management travel apps is likely to embrace hedonic motives as well as aspects of social responsibility and personal morality. Hence, this study investigates different motives as the backbone of user attraction and engagement.

The present study also includes technophilia which refers to "a person's openness, interest in and competence with (innovative) technologies". Technophile attitude comprises three components, namely affective (e.g. satisfaction, anxiety or enjoyment), behavioral (e.g., experience or frequency of use), and cognitive (e.g., technology self-efficacy*) (33).* Our study replaced technology self-efficacy by technophilia in the conceptual model since both terms represent personal factors. Previous literature supports the positive effect of technophile attitudes on user's behavior of innovative technologies. For example, the potential target groups for electric bike (*34*), electric vehicles (*35*) and advanced travel information systems (*33*) are people who are technophiles with an affinity to innovation and technology.

In line with TRD, our study integrates the three groups of user motives (i.e. functional, hedonic and normative), technophilia and adoption intention toward the travel app as the theoretical constructs and discovers the causal relationships between them. In other words, the present study investigates to what extent the conceptual model suggested by Zhu et al. (*20*), before-adoption phase, can be learned from data using causal analysis.

3. Survey design and participants

A tailor-made web-based questionnaire was designed according to the conceptual model. The survey elicited the following information; (1) the likelihood of using the app measured on a 5-point Likert scale ranging from highly unlikely to highly likely, (2) a set of user motives to use the app, (3) a technophile attitude captured by individual attributes of openness and interest toward smartphone apps, and (4) a set of background variables such as socio-economic information, travel habits, etc. The statements of the three groups of users' motives and technophilia were measured using the 5-point Likert scale ranging from strongly disagree to strongly agree.

With respect to the users' motives, respondents were asked the question, "how can the use of the new travel app help/enable you to achieve different travel goals for your daily commute". The first group, functional motives, incorporated items related to the functional value of the system to increase trip efficiency such as time savings for travelling and information searching, effort savings for searching information, and reducing travel cost. Trip efficiency was found as the most desired need for the users of travel information systems (*36*, *37*).

The second group, hedonic motives, explored motives regarding the game elements of the app including self-monitoring, information sharing and eco-point collection. As suggested by Muntean (*38*), the application of game elements in non-gaming systems combines two types of motives; "on one hand using extrinsic rewards such as levels, points, badges to improve engagement while striving to raise feelings of achieving mastery, autonomy and sense of belonging". By extension, Vassileva (*39*) suggested that social motivation also plays a role, such that the social aspects of such systems might influence user behavior. In our case study, social aspects could be related to the possibility of competition and social comparison provided by sharing information on social media.

The third group, normative motives, investigated items related to acting appropriately in line with sustainable travel behavior such as adopting environmentally-friendly travel alternatives and making contributions to the city's CO2 emission reduction.

Technophilia was measured with statements reflecting emotional and cognitive attitudes toward using smartphone apps. The statements were inspired by the work of Seebauer et al. (*33*) who investigated the attribute of technophilia in the context of online travel apps.

The survey was administered from 1st April to 1st May 2017 to a sample of commuters who were older than 18 and resided or worked in the greater Copenhagen area. The survey yielded 822 complete responses. Table 1 shows the sample characteristics. The sample characteristics are in line with the survey aim and scope to target commuters in the focus area.

Table 1. Sample characteristics, Total sample size = 822

Variable	Categories				
Gender	Male 54%	Female 46%			
Age	Age 18-29 36%	Age 30-39 20%	Age 40-49 19%	Age 50-59 17%	Age>60 8%
Education	High school 8%	Tertiary 16%	MT further 23%	LT further 53%	
Employment	Student 25%	Part time 6%	Full time 64%	Other 5%	
Family status	Single no children 21%	Couple no children 44%	Single with children 5%	Couple with children 30%	
Commute origin	Copenhagen 35%	Suburbs 40%	Rural 25%		
Commute destination	Copenhagen 30%	Suburbs 61%	Rural 9%		
Commute distance	0-5 km 19%	5-10 km 24%	11-20 km 31%	21-30 km 10%	> 30 km 16%
Annual income before tax (DKK)	Under 200,000 26%	200,000 – 400,000 25%	400,000 – 500,000 22%	500,000 – 750,000 18%	Over 750,000 9%

4. Methodological approach

This study considers probability distributions of the random vector $V = \{X_1, \dots, X_5\}$, consisting of the four attitudinal variables (i.e. three groups of users' motives and technophilia) and the adoption intention, that may be represented by a DAG. The random vector follows a multivariate normal distribution and the variables have a causal structure which is to be discovered from the data using the Max-Min Hill-Climbing (MMHC) algorithm (*17*). The MMHC is a hybrid algorithm and based on two steps. The first step, called restrict, learns the undirected skeleton by a constraint-based technique, namely the Max-Min Parents and Children (MMPC). The MMPC algorithm constructs the skeleton by executing a statistical conditional independence test between variables such as G^2 statistical test (*16*). If there is a subset S such that $X \perp Y|S$, two random variables X and Y are conditionally independent given S, then the skeleton does not add the edge between X and Y. If two random variables X and Y are conditionally dependent for any subset S, then the edge between X and Y is added in the skeleton. The second step, called maximize, is the edge orientation using a greedy hill-climbing algorithm within the restricted search space of the skeleton. Therefore, the search in the

MMHC algorithm to find the optimal DAG is constrained to only consider adding/deleting/reversing an edge that is remained after the restrict step.

5. Results

5.1. Factor analysis

The attitudinal constructs of the conceptual model were obtained by exploratory factor analysis (EFA). From a preliminary descriptive statistics analysis on the survey data, we observed good internal consistency with Cronbach's alpha 0.80 and good sampling adequacy with Kaiser-Meyer-Olkin (KMO) = 0.87. The determinant of the Spearman correlations matrix equal to 7.2E-9 also indicates absence of multi-collinearity, and Bartlett's test for sphericity rejected the null hypothesis of an identity correlation matrix. Principal axis factoring (PAF) with oblique "Promax" rotation generated the four factors presented in Table 2. The cut off of 0.5 was set to retain a set of items representing the factors.

Table 2. Rotated factor matrix

	Factors			
Item	F1	F2	F3	F4
reduce my travel time	**0.68**	-0.15	0.15	0.05
be on time	**0.79**	-0.2	0.19	0.01
pay less for daily transport	**0.54**	-0.02	0.26	-0.01
choose my travel mode according to the departure/ arrival time	**0.72**	-0.05	0.15	-0.05
be faster and more efficient trip	**0.77**	-0.15	0.15	0.06
get customized information about my preferred trips	**0.79**	0.16	-0.23	0.02
get cost information for each suggested trip	**0.72**	0.12	-0.03	0.00
get pop-ups with alternative travel modes/ routes, when there is disruption	**0.70**	0.22	-0.25	-0.03
reduce time spend and difficulty for travel information search	**0.78**	-0.01	-0.01	-0.02
arrive on-time	**0.86**	-0.07	-0.02	-0.01
be rewarded with bonus points for eco-friendly behavior	0.06	**0.55**	0.25	-0.05
monitor amount of calories burnt while travelling	-0.12	**0.65**	0.18	0.01
share information with other users	0.09	**0.62**	-0.08	0.08
share my saved CO2 emissions due to my eco-friendly behavior on the social media	-0.11	**0.75**	0.07	-0.02
use more public transport	0.25	0.01	**0.50**	-0.01
cycle more	0.00	0.03	**0.72**	0.03
make healthier choices	-0.03	0.26	**0.67**	0.03
reduce the CO2 level and air pollution in Copenhagen area	0.09	0.28	**0.53**	-0.05
I usually like to install interesting new apps	-0.01	-0.04	0.04	**0.85**
I regularly use apps for payments, reservations, errands etc.	-0.06	-0.01	0.00	**0.59**
I am enthusiastic about GPS and travel apps	0.09	0.04	-0.01	**0.62**
I think it is exciting to try new apps	0.00	0.06	0.01	**0.83**

Note: **bold** – highest factor loading for each item

As shown in Table 2, factor F1 "Functional motives" incorporates all statements related to the motives of increasing trip efficiency by using the travel app. Factor F2 "Hedonic motives" includes statements related to receiving feedback and rewards, as well as gaining social approval (i.e. sharing information) which reflects the users' perceptions of the value of the game elements. Factor F3 "Normative motives" is associated with the value of using the travel app to travel more environmentally-friendly. Factor F4 "Technophilia" includes four items related to technology-related self-concept.

5.1. Causal discovery

The structure was learned using the function of mmhc in the bnlearn package in R (*40*). The first step of the MMHC algorithm used significance test p<0.05, and the second step used BIC scores. The selected model is presented in Figure 3. All the edges are directed, meaning that there is no Markov equivalent. It is worth mentioning that the three groups of users' motives and technophile attitude were estimated based on structural equation modeling (SEM) and afterwards included for causal analysis.

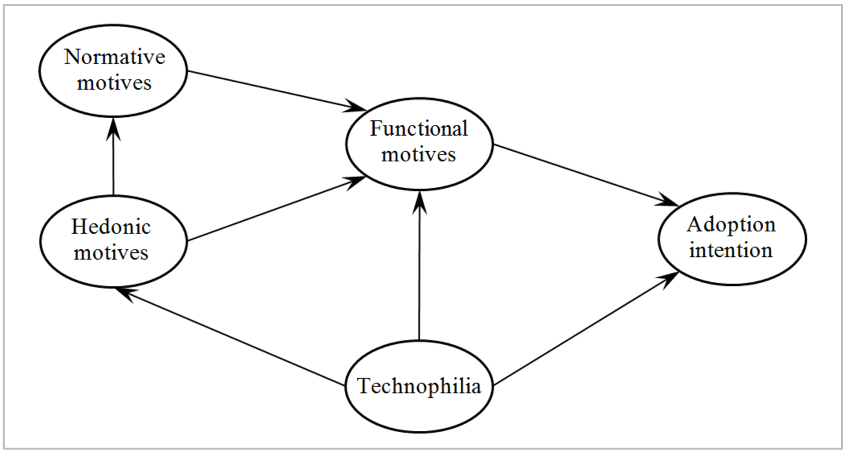

Figure 1. Estimated causal structure

6. Discussion and conclusion

According to Figure 3, the estimated causal structure shows that the two constructs of functional motives and technophilia have a causal effect on adoption intention. Likewise, technophilia is causally related to both functional and hedonic motives. The findings highlight the importance of the functional value of the system, as well as technology self-concept, as two important variables for adoption intention. Furthermore, the results indicate the effect of technophile attitude on developing both functional and hedonic motives. These findings agree with the self-efficacy based value adoption model developed by Zhu et al. (*20*); however, no dependency between technophilia and normative motives was established.

The causal structure shows hierarchical associations between the three groups of user motive. They can be explained by the "frustration-regression" principle according to Alderfer's ERG (Existence, Relatedness and Growth) theory of humans need (*41*). The ERG theory, which evolved from Maslow's theory of human motivation (*42*), is based on a threefold conceptualization of human needs: (i) Existence (i.e., functional needs), (ii) Relatedness (i.e., belonging, togetherness), and (iii) Growth (i.e., self-esteem, self-actualization). Unlike Maslow's hierarchy of needs, the ERG theory has the advantage of assuming that each of the three domains can be satisfied independently. The ERG theory has an element of "frustrations-regression" that is missing from Maslow's theory meaning that if a higher level need remains unfulfilled, a person may regress to lower level needs that appear easier to satisfy. In this context, according to the casual structure, the hedonic and normative values of the system are probably not perceived as appealing as its functional values. There might be issues in accomplishing the higher-order needs; hence users regress to functional motives. For example, users might believe that travel information systems, even this new generation, should continue to serve their traditional role, i.e. contribute to trip efficiency improvement. The complexity of the persuasive features of the travel app, subjectivity, might be another cause encouraging its adoption through developing the functional values.

The results have important practical implications. Since functional motives play a significant role in adoption behavior, the usefulness of the system for time savings (i.e. travelling and information searching), effort savings (i.e. searching information) and travel cost savings should thus be stressed throughout the process of system development, business design and marketing. The results also suggest that those people with higher affinity to information technology, on the one hand, perceive the values of mobility-management travel apps as more important, and on the other hand, are more likely to use the app, clearly characterizing technophiles as the key target group of this new generation of travel information systems. Edison and Geissler (*43*) argue that understanding individual differences in terms of technological affinity/aversion could be helpful for the design and promotion of high-tech products such as ATIS by "informing the design of user interfaces and functionalities", "enabling technophile early adopters for persuasive advertising", and "improving customer segmentation".

We are aware of the potential challenges of this method. For example, by increasing the number of variables, discovery of causal relationships from the observation might be challenging due to e.g. Markov equivalent classes. This challenge is even more critical for similar studies aiming at interpreting the discovered structure based on a behavior theory. Learning the structure directly from data may add undesirable associations between variables that are not interpretable. To deal with this, prior beliefs can be implemented in causal discovery algorithms by taking constraints on edges i.e., present, absent, fixed direction etc.

To conclude, this study shows the capability of causal discovery methods to learn the causal structure of theoretical frameworks, and accordingly interpret established associations. In this context, the proposed decision framework incorporates Alderfer's ERG theory of human needs and TRD to explain the use intention of mobility-management travel apps.

REFERENCES

1. Fogg, B. J. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann Publishers, San Francisco, 2003.

2. Fogg, B. *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '98*, 1998.

3. Gabrielli, S. et al. Design challenges in motivating change for sustainable urban mobility.*Comput. Human Behav.*, Vol. 41, 2014, pp. 416–423.

4. Jariyasunant, J. et al. Quantified Traveler: Travel Feedback Meets the Cloud to Change Behavior.*J. Intell. Transp. Syst.*, Vol. 19, No. 2, 2015, pp. 109–124.

5. Kazhamiakin, R. et al. *2015 IEEE First International Smart Cities Conference (ISC2)*, 2015.

6. Nakashima, R., T. Sato, and T. Maruyama. Gamification Approach to Smartphone-app-based Mobility Management.*Transp. Res. Procedia*, Vol. 25, 2017, pp. 2344–2355.

7. Arnott, B. et al. Efficacy of behavioural interventions for transport behaviour change: Systematic review, meta-analysis and intervention coding.*Int. J. Behav. Nutr. Phys. Act.*, Vol. 11, No. 1, 2014, .

8. Webb, T. L., J. Joseph, L. Yardley, and S. Michie. Using the Internet to Promote Health Behavior Change: A Systematic Review and Meta-analysis of the Impact of Theoretical Basis, Use of Behavior Change Techniques, and Mode of Delivery on Efficacy.*J. Med. Internet Res.*, Vol. 12, No. 1, 2010, pp. e4.

9. Andersson, A., L. Winslott Hiselius, and E. Adell. Promoting sustainable travel behaviour through the use of smartphone applications: A review and development of a conceptual model.*Travel Behav. Soc.*, Vol. 11, No. December 2017, 2018, pp. 52–61.

10. Sunio, V., and J.-D. Schmöcker. Can we promote sustainable travel behavior through mobile apps? Evaluation and review of evidence.*Int. J. Sustain. Transp.*, Vol. 11, No. 8, 2017, pp. 553–566.

11. Heckerman, D., D. Geiger, and D. M. Chickering. Learning bayesian networks: The combination of knowledge and statistical data.*Mach. Learn.*, Vol. 20, No. 3, 1995, pp. 197–243.

12. Pearl, J. *Causality: Models, Reasoning, and Inference, Second Edition*. Cambridge University Press, Cambridge, 2009.

13. Edwards, D. *Introduction to Graphical Modelling*. Springer New York, New York, NY, 2000.

14. Cooper, G. F. A simple constraint-based algorithm for efficiently mining observational databases for causal relationships.*Data Min. Knowl. Discov.*, Vol. 1, No. 2, 1997, pp. 203–224.

15. Silverstein, C., S. Brin, R. Motwani, and J. Ullman. Scalable Techniques for Mining Causal Structures.*Data Min. Knowl. Discov.*, Vol. 4, 2000, pp. 163–192.

16. Spirtes, P., C. N. Glymour, and R. Scheines. *Causation, prediction, and search.* The MIT Press, . 2nd Ed. 2000.

17. Tsamardinos, I., L. E. Brown, and C. F. Aliferis. The max-min hill-climbing Bayesian network structure learning algorithm.*Mach. Learn.*, Vol. 65, No. 1, 2006, pp. 31–78. Available at: http://link.springer.com/10.1007/s10994-006-6889-7.

18. Bandura, A. Social Foundations of Thought and Action: A Social-Cognitive View.*Acad. Manag. Rev.*, Vol. 12, No. 1, 1986, pp. 169–171. Available at: 10.5465/AMR.1987.4306538.

19. Bandura, A. The self system in reciprocal determinism.*Am. Psychol.*, Vol. 33, No. 4, 1978, pp. 344–358. Available at: http://content.apa.org/journals/amp/33/4/344.

20. Zhu, G., K. K. F. So, and S. Hudson. Inside the sharing economy.*Int. J. Contemp. Hosp. Manag.*, Vol. 29, No. 9, 2017, pp. 2218–2239. Available at: http://www.emeraldinsight.com/doi/10.1108/IJCHM-09-2016-0496.

21. Han, L., S. Wang, D. Zhao, and J. Li. The intention to adopt electric vehicles: Driven by functional and non-functional values.*Transp. Res. Part A Policy Pract.*, Vol. 103, 2017, pp. 185–197.

22. Axsen, J., and K. S. Kurani. Developing sustainability-oriented values: Insights from households in a trial of plug-in hybrid electric vehicles.*Glob. Environ. Chang.*, Vol. 23, No. 1, 2013, pp. 70–80.

23. Jansson, J., A. Marell, and A. Nordlund. Green consumer behavior: determinants of curtailment and eco-innovation adoption.*J. Consum. Mark.*, Vol. 27, No. 4, 2010, pp. 358–370. Available at: http://www.emeraldinsight.com/doi/10.1108/07363761011052396.

24. Koo, C., N. Chung, and K. Nam. Assessing the impact of intrinsic and extrinsic motivators on smart green IT device use: Reference group perspectives.*Int. J. Inf. Manage.*, Vol. 35, No. 1, 2015, pp. 64–79. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0268401214001005.

25. Yoon, C. Extending the TAM for Green IT: A normative perspective.*Comput. Human Behav.*, Vol. 83, 2018, pp. 129–139. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0747563218300384.

26. Morosan, C., and A. DeFranco. It's about time: Revisiting UTAUT2 to examine consumers' intentions to use NFC mobile payments in hotels.*Int. J. Hosp. Manag.*, Vol. 53, 2016, pp. 17–29.

27. Ozturk, A. B., A. Bilgihan, K. Nusair, and F. Okumus. What keeps the mobile hotel booking users loyal? Investigating the roles of self-efficacy, compatibility, perceived ease of use, and perceived convenience.*Int. J. Inf. Manage.*, Vol. 36, No. 6, 2016, pp. 1350–1359.

28. Wei-HanTan, G., and O. Keng-Boon. Gender and age: Do they really moderate mobile tourism shopping behavior?*Telemat. Informatics*, 2018, .

29. Chang, S. E., and W. C. Shen. Exploring smartphone social networking services for mobile tourism.*Int. J. Mob. Commun.*, Vol. 16, No. 1, 2018, pp. 63–81.

30. Hsiao, K.-L. What drives continuance intention to share location-based information?*Int. J. Mob. Commun.*, Vol. 15, No. 2, 2017, pp. 210–223.

31. Hsiao, K.-L., and C.-C. Chen. What drives smartwatch purchase intention? Perspectives from hardware, software, design, and value.*Telemat. Informatics*, Vol. 35, No. 1, 2018, pp. 103–113.

32. Hong, J.-C., P.-H. Lin, and P.-C. Hsieh. The effect of consumer innovativeness on perceived value and continuance intention to use smartwatch.*Comput. Human Behav.*, Vol. 67, 2017, pp. 264–272.

33. Seebauer, S., R. Stolz, and M. Berger. Technophilia as a driver for using advanced traveler information systems.*Transp. Res. Part C Emerg. Technol.*, Vol. 60, 2015, pp. 498–510.

34. Wolf, A., and S. Seebauer. Technology adoption of electric bicycles: A survey among early adopters.*Transp. Res. Part A Policy Pract.*, Vol. 69, 2014, pp. 196–211.

35. Hackbarth, A., and R. Madlener. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany.*Transp. Res. Part A Policy Pract.*, Vol. 85, 2016, pp. 89–111.

36. Grotenhuis, J.-W., B. W. Wiegmans, and P. Rietveld. The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings.*Transp. Policy*, Vol. 14, No. 1, 2007, pp. 27–38.

37. Vogelsang, S., C. Digmayer, and E.-M. Jakobs. *2015 IEEE International Professional Communication Conference (IPCC)*, 2015.

38. Muntean, C. C. I. Raising engagement in e-learning through gamification.*6th Int. Conf. Virtual Learn. ICVL 2011*, No. 1, 2011, pp. 323–329.

39. Vassileva, J. Motivating participation in social computing applications: a user modeling perspective.*User Model. User-adapt. Interact.*, Vol. 22, No. 1–2, 2012, pp. 177–201.

40. Scutari, M. Learning Bayesian Networks with the bnlearn R Package.*J. Stat. Softw.*, Vol. 35, No. 3, 2010, pp. 1–22.

41. Alderfer, C. P. An empirical test of a new theory of human needs.*Organ. Behav. Hum. Perform.*, Vol. 4, No. 2, 1969, pp. 142–175.

42. Maslow, A. H. A theory of human motivation.*Psychol. Rev.*, Vol. 50, No. 4, 1943, pp. 370–396.

43. Edison, S. W., and G. L. Geissler. Measuring attitudes towards general technology: Antecedents, hypotheses and scale development.*J. Targeting, Meas. Anal. Mark.*, Vol. 12, No. 2, 2003, pp. 137–156.