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Use intention of mobility-management travel apps: the role of users goals, technophile attitude and community trust

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Abstract

In recent years, persuasive interventions delivered through mobility-management tools have received attention as a means to motivate change for sustainable urban mobility. This paper aims to pinpoint and understand the drivers that influence individuals' travel decisions when using travel apps including both travel information and persuasive features. The analytical framework relies on Lindenberg's goal-framing theory in which individuals' motives for using travel apps are grouped into three overarching goals, namely (1) gain, (2) hedonic and (3) normative goal-frames. Furthermore, technophile attitude, community trust and place attachment are incorporated into the framework in order to better explain user-sided heterogeneity. The case-study focuses on the new travel information system in Copenhagen (Denmark). It questions 822 Danish travelers by distributing a technology-use preference survey. Structural equation models revealed that the choice motivators are specific to individual users and depend on wide ranging factors that go beyond traditional economic and socio-demographic methods. The study reveals: (i) trip efficiency improvement, enjoyment, social interaction and environmentally-friendly travel promotion are important motives for using the new app; (ii) individuals have different intentions according to the perceived value of the new information system as well as travel purposes; (iii) technophile attitude exerts a positive influence on both user motives and use intention; (iv) social and institutional trust in addition to an affective bond to the city influence the use intention of the travel app.

Keywords: ATIS; behavior change; travel information; structural equation; goal-framing theory

1. Introduction

The use of information-based mobility management strategies was suggested already in the beginning of the millennium but only in the last decade has gained momentum. Gärling et al. (2004, 2002) described a range of advanced traveler information systems (ATIS) for mobility-management, including navigation applications (apps) that notify the driver regarding route alternatives and alerts, share information regarding joint trips, real-time information regarding public transport, voluntary travel behavior change programs (VTBC) - also known as individualized marketing - and travel role-modelling through social networks. These information-based strategies, besides their low-cost for decision makers and wide availability to the general public, are potentially powerful from the behavioral perspective. Problem awareness by providing travelers with information affects perceived responsibility, behavioral control and social norms. This, in turn, affects behavioral intentions and actions (Bamberg et al., 2011; Eriksson et al., 2006). Hence, information technologies and individualized marketing are important tools toward sustainable travel behavior. Since they belong to commitment-oriented strategies, they are also more likely to be implemented because of their political acceptability (Gärling et al., 2004). They do not involve ethical and normative issues that usually impede public acceptance of pricing or monetary reward schemes (Di Ciommo et al., 2013; te Brömmelstroet, 2014). They encourage informed decisions, thus encouraging people to make a rational choice based on costs and benefits (Steg and Vlek, 2009), and make "the right choice for the right reasons" thus satisfying higher-order emotional needs of self-actualization that are important in long-term behavioral shifts (te Brömmelstroet, 2014). Further, tailor-made travel plans can alleviate contextual difficulties and induce temporary travel shifts so that people can reconsider their habitual behavior (Steg and Vlek, 2009).

This paper focuses on exploring the motivation to use a new real-time multi-modal travel app for Copenhagen, an ATIS for digital mobility-management assistance, aimed at encouraging travel behavior change. The new travel app, which is in the development stage, is a multi-faceted mobile app including both travel information and behavior change techniques such as health and environmental feedback, tailoring travel options, self-monitoring, tunneling users toward green behavior, social networking, nudging and gamification elements. Due to the collaborative feature of VTBC-based travel apps, a critical mass is essential for market penetration and use (see Dickinson et al., 2015). Meloni and Teulada (2015) describe three behavioral change elements that may induce target behavior by using ATIS: motivation, ability and triggers for behavioral change. A better grasp of the motivators and barriers for ATIS market penetration will aid authorities and private entrepreneurs to design effective and appealing ATIS, eventually translating into a wider potential of VTBC.

The success of behavior change techniques depends highly on understanding the underlying mechanism and processes of behavior change, i.e., why and how behavior change occurs and which driving forces and determinants guide behavior. Michie et al. (2008) indicated that behavioral theories and models of behavioral change deliver a useful basis for designing effective behavior change support systems (BCSS). Likewise, the importance of a theoretical foundation to promote sustainable travel behavior is highlighted by McFadden (2007) since it allows for a holistic

understanding of individual mobility behavior. Previous studies stressed the importance of a well-founded BCSS in behavioral theories, since the foundation positively and significantly influences its effectiveness (Andersson et al., 2018; Arnott et al., 2014; Webb et al., 2010). Nevertheless, as noted by Sunio and Schmöcker (2017) and Klein et al. (2014), there is a lack of research investigating “these new platforms for behavior change” (Fogg and Eckles, 2007) by the application of behavior theory. To the best of our knowledge, there are only few studies focusing on VTBC-based travel apps with support in behavioral theory, e.g., Dastjerdi et al., (2019), Andersson et al. (2018), Pronello et al. (2017) and Jariyasunant et al. (2015). Thus, more research is needed to ensure the efficacy of this “next generation” traveler information systems (Kramers, 2014) for supporting sustainability-oriented decisions.

Given the gap in current literature, this study contributes to the body-of-knowledge by offering to explore Lindenberg’s goal-framing theory (Lindenberg, 2006; Lindenberg and Steg, 2007) as a motivator for the intentions to use mobility-management travel apps. This study follows the same line of research as Pronello et al. (2017) who propose the theory of planned behavior (TPB) to explain the use of the "Optimod’Lyon" multi-modal travel app by linking beliefs and behavioral intentions. We use the goal-framing theory, arguing that information processing and behavior are guided by three overarching goals, namely gain goal “to guard and improve one's resources”, hedonic goal “to feel better right now”, and normative goal “to act appropriately”. The three overarching goals agree with popular theories and models employed for technology adoption behavior, which usually incorporate only one group of motives. The TPB argues that individuals are usually motivated by self-interests and that their engagement in actions rests on weighing the expected costs and benefits, which makes it comparable with the gain goal. The goal-framing theory complements the TPB by incorporating hedonic and normative goals which are in accord with, respectively, intrinsic motives in self-determination theory (SDT; Deci and Ryan, 2000) and altruistic motives in Norm Activation Model (NAM; Schwartz, 1977). Hence, as recommended by Dickinson et al. (2015), this study identifies different groups of user motives, in line with the goal-framing theory, as backbone for user attraction and engagement.

The paper is organized as follows: Section 2 provides a literature review of some available mobility-management travel apps. Section 3 presents and discusses the motivational factors to adopt the new system and describes the proposed theoretical framework and corresponding hypotheses. Section 4 presents the mathematical model (i.e. Structural Equation Modelling) for testing the hypotheses. Sections 5 and 6 introduce the case study, survey design, data collection, as well as sample descriptions. Section 7 presents the results and discussions followed by policy implications in Section 8. Limitations and future directions are placed in Section 9 and finally, Section 10 concludes the paper.

2. Literature review

Traditional VTBC solutions require person-based interaction, either by phone or home interviews, which is inherently expensive and may induce biases stemming from social interaction and communication. ATIS-assisted VTBC offers opportunities to reduce the costs associated with the need for human-based interaction. The widespread Internet connectivity, the common use of

smartphones, and the frequent use of mobile travel apps provide an opportunity for producing a critical mass for VTBC-based ATIS. While most travel apps are still based on the traditional view of digitized traffic information, the newest generation of ATIS includes user-based alerts, prescriptive advices (e.g., route alternatives and changes), reflective memory (e.g., the ability to save past and future trips and locations), and persuasive strategies inspired by Fogg's framework (Fogg, 1998, 2003) in which the system design is persuasive and explicitly attempts "to change attitudes or behaviors or both (without using coercion or deception)". This is achieved by raising the awareness of individual choices, patterns, and the consequences of activities. Persuasive technologies, also termed as BCSSs, 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. Travel mobile apps incorporating persuasive strategies are currently under development and offer functions for

- i. Self-monitoring and feedback in terms of health and environmental information, e.g., SUPERHUB (Gabrielli and Maimone, 2013), IPET (Meloni et al., 2014), Peacox (Bothos et al., 2014), Quantified Traveler (Jariyasunant et al., 2015), Tripzoom (Poslad et al., 2015), MM (Nakashima et al., 2017) and Optimum (Anagnostopoulou et al., 2018)
- ii. Challenges & goal setting, e.g., SUPERHUB, Peacox and TRIPZOOM,
- iii. Tailoring information according to the user's needs, usage context and interests, e.g., SUPERHUB, IPET and Peacox,
- iv. Social comparison & networking, e.g., Quantified Traveler, SUPERHUB, Peacox, TRIPZOOM, MM, Optimum, and
- v. Gamification & rewards, e.g., SUPERHUB, Peacox, ViaggiaRoveretgoto (Kazhamiakin et al., 2015), TRIPZOOM, MM, and SMART (Huang et al., 2018).

Although these new solutions may produce concerns regarding technology, privacy, reliability (Gadziński, 2018) and unintended externalities (te Brömmelstroet, 2014), field experiments provide evidence that these new features are important for influencing users to change their travel behavior (Gabrielli and Maimone, 2013; Jariyasunant et al., 2015; Kazhamiakin et al., 2015; Poslad et al., 2015; Nakashima et al., 2017; Huang et al., 2018).

Gabrielli and Maimone (2013) explored the impact of the "SUPERHUB" mobile app on transport choices and habits through a small pilot study in Switzerland. By analyzing mobility habits logs as well as interviews, they found a modest increase (14%) in "sustainable transport choices" over a period of one month. However, its long-term effect to change and maintain the desired behavior is an important issue. Jariyasunant et al. (2015) investigated the implementation of a mobility-management tool named "Quantified Traveler" applied in San Francisco Bay. The Quantified Traveler has a computer-based platform for travel diary collection and feedback through a mobile app; it still relies much on human assisted travel tailoring. A three-week field experiment proved that, among participants, "Quantified Traveler" is useful to significantly reduce the car mileage, and to a lesser extent to encourage walking/cycling. Kazhamiakin et al. (2015) explored the use of "ViaggiaRoveretgoto", a gamified intervention mobile app, to change travel behavior in terms of route and mode choices through a control experiment during five weeks. The analysis of the system logs showed that gamification could increase engagement and possibly promote sustainable

mobility behaviors. Poslad et al. (2015) studied the impact of different travel incentives through the use of the “Tripzoom” app to motivate users to embrace sustainable mobility in the cities of Enschede, Gothenburg and Leeds for a period of six months. The main findings support the effectiveness of the incentives to encourage travel behavior change. Providing users with customized information, feedback and goals aligned with their specific needs was found essential to trigger behavior change. Additionally, an appealing and simple design appeared to be important to the users. Nakashima et al. (2017) investigated the effect of the mobile app “MM” in changing travel behavior (i.e. increasing number of steps) through a before-after study design. The app’s persuasive features include gamification and comparison offering the possibility of scoring, ranking and competition. The results revealed that the app effectiveness for changing behavior depends on users’ current walking behavior as well as their personality traits. More specifically, the app was effective for people who do not usually walk too much and particularly for people who have a competitive nature. Huang et al. (2018) studied the impact of persuasive incentives delivered through the “SMART” mobile app, on cycling behavior in the Twente region in the Netherlands. The gamification and rewards functions of the app were reported to affect travel behavior and increase cycling. Furthermore, providing customized incentives according to the users’ travel pattern was found important for triggering behavior change.

3. Theoretical framework

3.1. Goal-framing theory

In an environmental context, the goal-framing theory argues that behavioral motives can be divided into three overarching categories of goals (i.e. “goal-frame”) according to the core desires and needs that they satisfy: gain, hedonic and normative motives. The goals, which are likely to be situation-dependent instead of stable across situations, govern or frame “the way in which people process information and act on it”. Consequently, they influence individuals’ attitudes, feelings and actions.

The gain goal-frame implies the desire to guard or improve one’s resources reflecting more strategic and calculative intentions to improve one’s situation in the longer run. If this goal-frame is prevailing, individuals are focused on the prospect of gaining benefits for their own interest. Individuals in a hedonic goal-frame desire to maintain or improve feelings in the short-term and the goal motivates them to improve their situation at the moment in terms of pleasure and mood. The normative goal-frame bears on the motives to guard and improve goals of the collective, act morally, behave adequately and conform to social norms and rules.

The theory suggests that the three goal-frames and their motives are simultaneously present and active. However, only one goal-frame is dominant at any given time, which determines the way individuals interpret and frame the situation and how they act. Motives belonging to the other two goal-frames are present in the background and seem to interfere with the dominant one. The background goal-frames either promote (i.e. compatibility situation) or weaken (i.e. conflict situation) the main one, thereby affecting the action.

Previous empirical studies, as presented in the next two paragraphs, investigated how different types of motives are related to technology adoption behavior. When it comes to sustainable

innovations, Han et al., (2017) showed that gain motives (e.g., monetary, performance and convenience) have both direct and indirect effects on consumers' intention to adopt electric vehicles, whereas hedonic motives (e.g., enjoyment, pleasure, social acceptance) and normative values have only indirect effects on the adoption intention. However, Axsen and Kurani (2013) and Jansson et al. (2010) showed that people's willingness to adopt alternative fuel vehicles is significantly influenced by the environmental values (i.e. normative motives) they endorse. Koo et al. (2015) investigated the impact of intrinsic and extrinsic motivators on smart green IT device use. They found that perceived enjoyment strongly correlates with the perceived usefulness which, in turn, translates into its adoption i.e. indirect effect of hedonic motives on users' behavior. In another study by Yoon (2018), perceived usefulness and personal norms were modelled in order to investigate individuals' intention to use green IT. The results showed that the use intention is driven by both gain and normative motives.

In the context of mobile information technologies, Zhu et al. (2017) investigated important factors that influence adoption of ridesharing applications. They showed that gain motives (e.g. time and monetary savings) together with hedonic motives (i.e. enjoyment and social image improvement) significantly influence the overall perceived value of ridesharing applications. Gain and hedonic motives were also identified in recent studies as important antecedents of intention to adopt mobile devices such as mobile applications for booking/shopping purposes (e.g. Agrebi and Jallais, 2015; Morosan and DeFranco, 2016; Ozturk et al., 2016; Wei-HanTan and Keng-Boon, 2018), mobile social networking services (e.g. Chang and Shen, 2018; Hsiao et al., 2016; Hsiao, 2017) and smartwatches (Hong et al., 2017; Hsiao and Chen, 2018).

While simple navigation apps are mostly driven by their functional value, the use of VTBC-based travel apps is likely to embrace hedonic motives as well as the aspects of social responsibility and personal morality. The application of the goal-framing theory, as explained in the introduction section, allows considering the diversity of behavioral motives in order to better elucidate the users' behavior when using mobility-management travel apps. A number of recent studies employed the goal-framing theory to explain individual environmentally responsible decision-making in the domains of transport (e.g. Bösehans and Walker, 2018; Geng et al., 2017; Han et al., 2016) and energy (e.g. Dóci and Vasileiadou, 2015; Polhill and Gotts, 2017). Hence, this study investigates different motives within the framework of the goal-framing theory as backbone for user attraction and engagement. We also hypothesized that depending on the situation (which in this paper, as explained in Section 6, are different travel purposes), different motives guide the use of VTBC-based travel apps

3.2. Technophilia

Consumer attitudes and psychological factors can be critical for the marketing of innovative technologies which may affect their success. With the purpose of analyzing these factors, we investigated the role of technophilia, an attitude toward technology referring to “a person's openness, interest in and competence with (innovative) technologies” (Seebauer and Berger, 2010). Therefore, the definition of technophilia is aligned with the ABC model of attitudes (Eagly and Chaiken, 1993) in which the technophile attitude has three components namely, affective (e.g.,

satisfaction, anxiety or enjoyment), behavioral (e.g., experience or the frequency of usage), and cognitive (e.g., technology self-efficacy). Technophilia as a personal driver has been studied in the research on ICT adoption behavior for many years.

Technology self-efficacy as the cognitive attribute of technology affinity is a personal belief in one's ability to successfully perform or learn a task when dealing with a technological device (McDonald and Siegall, 1992). This concept emerged from Social Cognitive Theory (SCT; Bandura, 2012, 1982). Previous empirical studies investigated the effect of technology self-efficacy to predict the use of mobile applications (Alalwan et al., 2016; Dasgupta et al., 2011; Ozturk et al., 2016a, 2016b; Shareef et al., 2018; Yu, 2014; Zhu et al., 2017, 2010). The findings of these studies support a positive effect of technology self-efficacy on user attitude and behavior. Previous literature also relates the acceptance of ICT to affective attitudes like anxiety (e.g., Briz-Ponce et al., 2017; Celik, 2016; John, 2015), enjoyment (e.g., Sánchez-Prieto et al., 2016; Zhang et al., 2015) and satisfaction (e.g., Pindeh et al., 2016; Yoon, 2016) as well as behavioral aspects (e.g., Goulías et al., 2004; John, 2015).

Zhu et al. (2017) conceptualized a behavioral model to investigate the factors influencing the use of ridesharing mobile apps. The SCT was used as the underpinning theory arguing that human behavior both influences and is influenced by personal factors and the environment, i.e. a triadic reciprocal relationships. In their proposed framework, personal factors and the environment were presented by technology self-efficacy and perceived value, respectively. Figure 1 displays the triadic reciprocal relationships in which the solid and dotted lines denote before-adoption and post-adoption, respectively.

Figure 1. Self-efficacy based value adoption model (source: Zhu et al., 2017)

In before adoption phase, which is relevant to our study, while perceived value has direct effect on behavior, technology self-efficacy is the antecedent of both perceived value and behavior. Previous literature supports both direct (e.g. Dasgupta et al., 2011; Seebauer et al., 2015) and indirect (e.g. Alalwan et al., 2016; Ozturk et al., 2016b, 2016a; Yu, 2014) effects of technology affinity on user behavior. Therefore, we hypothesized that technophilia has a positive (direct and indirect) relation with the use intention of VTBC-based travel apps, i.e. both adoption and situational use intentions.

3.3. Trust and place attachment

One of the main limitations of persuasive technologies is their focus on targeting specific behaviors and choices of individuals instead of proposing more collective approaches that, address the relevant communities that could have a higher impact on adoption (Gabrielli et al., 2014; Brynjarsdottir et al., 2012; DiSalvo et al., 2010; Dourish, 2010). This limitation narrows “the vision of sustainability” since it frames users as individuals while disregarding the multifaceted social, cultural, and institutional contexts in which they live. The exclusive focus on users’ responsibility for sustainable practice is prone to disregard the social dynamics outside the system condition and the need for change at other scales beyond the individual users (Hekler et al., 2013; Mogles et al., 2018; Pierce et al., 2010; Strengers, 2011, 2008).

To enrich the theoretical framework as well as to address this limitation, we incorporated the notion of institutional and social trust into the model. Social trust refers to trust between individuals and the community at large, while institutional trust is the trust that individuals place in organizations and institutions. The importance of trust and its role as motivator for goal-directed behavior were highlighted by previous studies since trust reinforces peoples’ engaging behavior, i.e. acceptability and public involvement (Hsu et al., 2012; Steg et al., 2015). Previous literature investigated the role of these two forms of trust in relation to environmental policy, their acceptance and public engagement (Adaman et al., 2011; Brondizio et al., 2009; Jones, 2010; Pretty and Ward, 2001; Taniguchi and Marshall, 2018; Wynveen and Sutton, 2015). Trust is also contextual and may vary among issues, resources, or communities (Winter et al., 1999). Therefore, a better understanding of social/institutional trust could help in alleviating trust barriers to VTBC-based travel apps as a collaborative technology. However, the relationship between these two constructs is the main problem with trust research and there is no general agreement on what the cause is and what the effect is. In our behavioral framework, the causal relation is grounded on the findings of the recent study conducted by Sønderskov and Dinesen (2016) in Denmark suggesting that institutional trust shapes social trust, while the evidence for a reverse relationship was limited.

Place attachment is another factor often assumed to affect residents’ attitude and behavior in relation to local issues and collaborative actions. Place attachment refers to an affective bond that people establish with a specific place and it is widely viewed as an important part of human identity. Considering people’s emotional connections with the city may provide a better understanding of their motivations, reactions to, and participation in local community-based action (Manzo and Perkins, 2006; Pretty, 2003; Scannell and Gifford, 2013). In this context, there are some empirical studies showing the importance of place attachment to motivate cooperative pro-environment action (e.g., Gosling and Williams, 2010), to support city management interventions (e.g., Devine-Wright, 2009; Verbrugge and van den Born, 2018) and to predict residents’ engagement with climate change adaptation and mitigation activities at a local scale (e.g., Amundsen, 2015; Scannell and Gifford, 2013).

As suggested by Ajzen and Fishbein (1980) as well as Bamberg (2003), general attitudes do not have a direct effect on specific behaviors, but they are indirect determinants through situation-specific beliefs, operating via their impact on “the generation of situation-specific cognition”. In

this paper, trust and place attachment are general attitudes. Therefore, we investigate their effects on the use intentions of VTBC-based travel apps mediated by the three goal-frames.

3.4. Conceptual model and the hypotheses

Based on the above literature support, we develop a conceptual behavior model to better explain user-sided heterogeneity observed in individual behavior, and to effectively evaluate VTBC-based travel apps for possible adoption. Figure 2 describes the conceptual model in which three different groups of user motives, technophile attitude and the social dynamic outside the system condition are important determinants for adoption behavior. The hypotheses related to the model are proposed as follows:

H1: Gain, hedonic and normative goals motivate VTBC-based travel app use intentions

H2: Technophilia relates positively to use intentions

H3: Technophilia relates positively to goal-frames

H4: Social trust, institutional trust and place attachment have an effect on use intentions, mediated by goal-frames

H5: Institutional trust shapes social trust in the context of transport

Figure 2. Conceptual model of motivations for using mobility-management travel apps

4. Mathematical model

The behavioral model structure representing the research hypotheses was investigated by applying structural equation modeling (SEM). SEM is a confirmatory analysis technique that tests models that are conceptually derived beforehand, and evaluates how well the theory fits the collected data (Hair et al., 2006). SEM foundations lie in two multivariate techniques: confirmatory factor analysis (CFA) and multiple regressions, also called path analysis, that test measurement and structural equations simultaneously. The measurement equations denote relations between latent constructs and their respective indicators while structural equations represent the directional relations between

latent constructs (refer to Bollen (1989) for details about SEM). An increasing number of recent studies employed SEM to examine the use of travel mobile apps (e.g., Assemi et al., 2018; Dastjerdi et al., 2019; Fang et al., 2017; Im and Hancer, 2017).

In this study, the model is constructed by four equations that we explain below.

$$I_{rn} = Z_{ln}^* \alpha_r + v_{rn} \quad \text{and} \quad v_{rn} \sim N(0, \Sigma_v) \quad \text{for } r = 1, \dots, R \quad (1)$$

$$Z_{ln}^* = X_{ln} \beta_l + \omega_{ln} \quad \text{and} \quad \omega_{ln} \sim N(0, \Sigma_\omega) \quad \text{for } l = 1, \dots, L \quad (2)$$

$$Z_l^* = Z_i \beta_i + \varphi_l \quad \text{and} \quad \varphi_l \sim N(0, \Sigma_\varphi) \quad \text{for } l = 1, \dots, L \text{ \& } i = 1, \dots, K \quad (3)$$

$$Y_n = Z_{ln}^* \gamma_Z + \xi_n \quad \text{and} \quad \xi_n \sim N(0, \sigma_\xi^2) \quad (4)$$

Where Eq. (1) links the measurement indicators (i.e. questionnaire items) to the latent constructs. I_{rn} refers to the value of an indicator r related to latent construct Z_{ln}^* as perceived by respondent n . The value of latent construct l for respondent n is labeled with Z_{ln}^* and α_r is the corresponding factor loading. The error term is expressed as element v_{rn} which is a vector following a normal distribution with covariance matrix Σ_v . Eq. (2) links the latent constructs Z_{ln}^* to individual characteristics. X_{ln} is a vector of the respondents' individual characteristics (e.g. socio-economic and travel habit) and β_l are the parameters representing the regression relations. The error term is ω_{ln} which is a vector following a normal distribution with covariance matrix Σ_ω . Eq. (3) relates the explanatory latent constructs Z_i (e.g., technophilia, institutional trust, social trust and place attachment) with the mediator latent constructs Z_l^* (e.g. the goal-frames) through parameters β_i . The error term is φ_l following a normal distribution with covariance matrix Σ_φ . Eq. (4) represents regression relations between the latent constructs Z_{ln}^* and the target variable Y_n through parameters γ_Z . Here, Y_n is the likelihood level of using the app by respondent n (i.e. in 1-5 Likert scale from highly unlikely to highly likely). The error term is presented as ξ_n .

The commercial software M-Plus was used to estimate the model parameters (Muthén and Muthén, 2012). The parameters of the four sets of equations were estimated simultaneously by Mean-and Variance-adjusted Weighted Least Squares (WLSMV) due to the violation of normally distributed data for all items according to the Mardia's test for multivariate normality, and because it provides the best option when modelling ordered data such as 5-point Likert data (Brown, 2006). The goodness-of-fit was measured using three different indices including the Comparable Fit Index (CFI) (Hu and Bentler, 1999), the Root Mean Square Error of Approximation (RMSEA) (Browne and Cudeck, 1992) and the Standardized Root Mean Square Residuals (SRMR) (Bollen, 1989).

5. Case study

To promote sustainable mobility in the city of Copenhagen, different policy instruments aiming at reducing car travel demand and increasing the efficiency of transport have been launched. Development of the “world's best city for cyclists” concept, the introduction of intelligent traffic control and information systems, improvement of the public transport system and support for the

use of electricity and hydrogen powered cars are some examples. As a result, in the five year period between 2010 and 2015, transport-related CO₂ emissions were reduced by 9%, the number of kilometers driven by car was reduced by 3% and cycle traffic increased by 12% (City of Copenhagen, 2016).

Currently, the city is pursuing the CPH 2025 Climate Plan, encompassing a collection of specific goals for CO₂ reductions in mobility by 2025. The targets are (i) 75% of all trips in Copenhagen are on active modes or public transport, (ii) 50% of all trips to work or school in Copenhagen are by bike, and (iii) 20% more passengers use public transport compared to 2009 (Ibid). Improving the city's travel information system is now being considered as an additional measure for supporting a larger adoption of sustainable mobility choices. The Copenhagen strategy is in line with the recent developments of "Mobility as a Service (MaaS)" and the European Union (EU) target (EU, 2011) that establishes a framework for multimodal transport information, management and payment systems allowing for change toward a more sustainable and multi-modal transport system.

Hence, a new advanced real-time multimodal travel app is under development for Copenhagen. The idea behind the system is to integrate traffic information and journey planning to include all modes of transport. From the demand side it includes multi-modal real-time information, multi-criteria route planning on the basis of time, cost, emission and caloric expenditure, multi-modal choice combinations, ridesharing opportunities, easy payment, provision on socio-technical feedback through the ability to share information with social networks, and gamification elements such as point scoring and a loyalty program. From the supply side it produces information feedback to infrastructure planning and traffic management. The main added value of this new travel information system compared to the available ones in the city (e.g., Google Maps, Rejseplanen and I bike CPH) is related to the integrated persuasive features aiming at promoting sustainable mobility behavior (For more PPI ITS Project, 2014).

More specifically on the persuasive features, the new travel app provides travelers with information about CO₂ emissions produced/saved by choosing different travel options and the amount of calories burnt by taking active modes. The app users can also monitor CO₂ savings and calories consumption over time. Moreover, the app enables its users to register for an environmentally-friendly loyalty program: the more environmentally-friendly the itinerary, the more bonus points they earn. The bonus points can be used to get 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. The willingness to participate in the environmental loyalty program is described by Dastjerdi et al. (2019).

6. Survey design and participants

A tailor-made web-based questionnaire was designed according to the developed behavioral framework. The survey provided information related to the functionalities and features of the new travel app such as multimodal travel information, incorporated persuasive strategies, bonus points, the policy of monitoring their travel behavior etc. The survey elicited the following information; (i) the likelihood of using the app measured on a 5-point Likert scale ranging from highly unlikely to

highly likely, (ii) a set of user motives for using the app to estimate the constructs in relation to the goal-framing theory, (iii) technophile attitude captured by individual attributes of openness and interest toward smartphone apps, (iv) individuals' attitude of social trust, institutional trust and place attachment measured by the concept of community resilience and (v) background information about socio-economic characteristics, travel habits, and the use of travel information. The statements of the attitudinal variables were measured using the 5-point Likert scale ranging from strongly disagree to strongly agree.

Regarding the use intention, respondents were asked to rate the likelihood of using the app for their daily commute and for specific travel purposes, because the goal-framing theory suggests that the goals are likely to be situation-dependent instead of stable across situations. Incorporating travel purposes in the model enabled us to examine how their effects vary according to the trip purpose.

With respect to the goal-framing theory, respondents were asked how using the new travel app can help/enable them to achieve different travel-related goals.

The gain goal-frame 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 travel cost savings. Previous studies presented trip efficiency as the most desired need for the users of travel information (Chorus et al., 2007; Grotenhuis et al., 2007; Vogelsang et al., 2015).

The hedonic goal-frame explored motives regarding the game elements of app including self-monitoring, information sharing and bonus point collection. As suggested by Muntean (2011), the application of gamification elements in non-gaming systems combines two type 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 (2012) suggested that social motivation also plays a role, such that the social aspect of such systems might influence user behavior. For example in our case study, social motivations could be related to the possibility of competition and social comparison provided by sharing information on social media. In the field of social psychology, sociology and marketing, this is known as social value reflecting the (positive or negative) outcomes of the ownership and use of a product for one's (self-) identity and social status. It is viewed as the product's ability to develop social self-concept (Belk, 1988; Dittmar, 1993; Park et al., 1986; Sirgy, 1986).

The normative goal-frame investigated items related to acting appropriately in line with sustainable travel behavior such as adopting more environmentally-friendly travel alternatives and contributing to the city's CO2 emission reduction.

Technophilia was measured using statements reflecting emotional and cognitive attitudes toward the use of smartphone apps. The statements were inspired by the work of Seebauer et al. (2015) who investigated the attribute of technophilia in the context of online travel apps. We did not consider the behavioral aspects of technophilia, because Denmark has a high smartphone penetration rate (i.e. a penetration rate of over 77% among the general population according to

eMarketer's worldwide mobile forecast). Furthermore, there is high tendency among Danish smartphone holders to use mobile apps in their daily life as shown by a recent survey in Denmark. The survey showed that social networking applications (i.e. Facebook), payment applications (i.e. MobilePay) and travel planning applications (i.e. Rejseplanen and Google Maps) are among the top ten popular apps that smartphone users "can least do without", regardless of age group (Jacobsen, 2017).

We assess the last group of attitudinal variables using the concept of community resilience, originally developed by Leykin et al. (2013) for community disaster management. In our study, the notion of community resilience entails four constructs, i.e. leadership, collective efficacy, preparedness and place attachment. The statements related to each construct were shortened and adapted to the context of transport. The institutional trust includes leadership and preparedness (e.g. Leadership: "I have trust in information provided by the public transport authority"; Preparedness: "The transport system of my city is well-organized to be sustainable") while the social trust includes collective efficacy e.g., "I can count on people in my community to travel in an environmentally sustainable manner"); Place attachment was also articulated in the transport context: "Participating in transport-related test projects in my city is important to me").

Individual characteristics comprised socio-economic variables, travel habits, past travel experiences and information use habits. The travel habits included the frequency of traveling by car, public transport and bicycle as well as the frequency of commuting with others. The frequency was measured on a 5 Likert scale including never/rarely, less than 3 days a month, once a week, 2-3 days a week and daily. The respondents were also asked about their perceived time of the modal choice and situational attributes, namely the commuting distance. The travel information use habits included the frequency of consulting with travel information systems for commuting by car, public transport and bicycle. The frequency of information use was measured on a 5 Likert scale from never to always.

The survey was administered from 1st April to 1st May 2017 to a sample of commuters who older than 18 and residing or working in the greater Copenhagen area. Technical University of Denmark (DTU), Copenhagen municipality and a number of companies were selected. As for the individuals who either worked or studied at the university, the email addresses were accessible. Therefore, they were contacted directly. The questionnaire was distributed among the companies registered in the list of the Danish Bureau of Statistics which is available online. Companies with more than ten employees located in the region were included. As part of the recruitment, more than 5,000 email invitations were sent. Copenhagen municipality also posted the questionnaire on their employee portal which allowed obtaining a larger sample size.

The 822 completed responses can be considered as an adequate sample size based on a rule of thumb of requiring 10 responses for each of the 41 indicators designed for our study (Nunnally et al., 1967). Table 1 shows the sample characteristics compared to the data from the Danish National Travel Survey (TU) for the same region.

Table 1. Descriptive statistics of the sample and comparison with TU survey

		Sample (%) (N=822)	Danish national travel survey (%) (N=8511)	Difference between samples	
				χ^2	p-value
Gender	Male	54%	49%	7.55	0.006
	Female	46%	51%		
Age	18-29	36%	23%	110.44	<0.001
	30-39	20%	21%		
	40-49	19%	20%		
	50-59	17%	16%		
	60+	8%	20%		
Education	High school	8%	12%	479.45	<0.001
	Tertiary	16%	38%		
	MT further	23%	30%		
	LT further	53%	20%		
Employment	Student	25%	12%	242.58	<0.001
	Part time	6%	11%		
	Full time	64%	54%		
	Other	5%	23%		
Family status	Single no children	21%	30%	63.65	<0.001
	Couple no children	44%	31%		
	Single with children	5%	5%		
	Couple with children	30%	34%		
Commute origin	Copenhagen	35%	37%	17.92	<0.001
	Suburbs	40%	33%		
	Rural	25%	30%		
Commute destination	Copenhagen	30%	44%	290.24	<0.001
	Suburbs	61%	32%		
	Rural	9%	24%		
Commute distance	0-5 km	19%	39%	441.16	<0.001
	5-10 km	24%	17%		
	11-20 km	31%	11%		
	21-30 km	10%	4%		
	More than 30 km	16%	29%		
Annual income before tax (\$) *	Under 30,000	26%	28%	77.81	<0.001
	30,000 - 60,000	25%	37%		
	60,000 - 75,000	22%	16%		
	75,000 - 112,500	18%	14%		
	Over 112,500	9%	5%		

* In the survey, we separated different income groups based on Danish currency (DKK). In this Table, the exchange rate for DKK to US dollar is 0.15.

The sample characteristics are in line with the survey aim and scope to target adult commuters in the Greater Copenhagen Area. The sample mostly includes adults who are full-time employees or students. Our sample is considerably different from the TU data. This was to be anticipated due to the choice of recruitment. For example, almost one fourth of the participants are students. They are typically young and therefore, in our sample, the share of age group (18-29) is higher than in the TU data. Correspondingly, it influenced other categories as well. Another reason can be related to the recruitment of employees which implemented through companies not contacted them directly.

7. Results

7.1. Factor analysis

All the constructs of the behavioral framework including the goal-frames, technophilia, social and institutional trust and place attachment were obtained by exploratory factor analysis (EFA). EFA was employed to expose the underlying structure of the variables and investigate the theoretical constructs.

The survey data showed good internal consistency with Cronbach's alpha 0.9 and good sampling adequacy with Kaiser-Meyer-Olkin (KMO) = 0.9. The determinant of the Spearman correlations matrix, equal to 2.17E-07, established the absence of multi-collinearity, and the Bartlett's test for sphericity rejected the null hypothesis of an identity correlation matrix. Principal axis factoring with oblique "promax" rotation generated the seven factors presented in Table 2, including three factors of the goal-frames, a factor of technophile and three factors related to the community context: social trust, institutional trust and place attachment.

Table 2 shows the generated factors, the factor loadings of the dominant items and their descriptions. The complete rotated factor matrix is presented in Appendix A. The cut off of 0.3 was set to retain a set of items representing the factors. The Cronbach's alpha of each factor is also presented in brackets. All the Cronbach's alpha values are above 0.7 reflecting good internal consistency (Miller, 1995).

As shown in Table 2, factor F1 "Gain motives" incorporates all statements related to the goal-frame of increasing trip efficiency by using the travel app. Factor F2 "Hedonic motives" includes statements related to receiving a feedback and reward as well as gaining social approval (i.e. sharing information) which reflects 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. Factor F5 is formed by six items related to "Leadership" and "Preparedness" constructs of the community resilience. The two constructs reflect institutional trust since they describe trust belief toward the transport planning and services provided by public institutions. F6 includes three items associated with "Collective efficacy", reflecting social trust, as the shared belief that the members of the community will effectively cooperate and work toward making the city more sustainable. F7 "Place attachment" is associated with the individual's willingness to be updated about transport-related projects and engage in the related voluntary activities in order to contribute to sustainable development of the city.

Table 2. Rotated factor matrix for attitudinal variables

Factor name (Cronbach α)	Acronym	Item	Factor loadings
F1 (0.92) Gain motives	GM1	reduce my travel time	0.72
	GM2	be on time	0.83
	GM3	pay less for daily transport	0.56
	GM4	choose my travel mode according to the departure/arrival time	0.75
	GM5	be faster and more efficient trip	0.80
	GM6	get customized information about my preferred trips	0.77
	GM7	get cost information for each suggested trip	0.71
	GM8	get pop-ups with alternative travel modes/routes, when there is disruption	0.67
	GM9	reduce time spend and difficulty for travel information search	0.80
	GM10	arrive on-time	0.89
F2 (0.78) Hedonic motives	HM1	be rewarded with bonus points for eco-friendly behavior	0.42
	HM2	monitor amount of calories burnt while travelling	0.65
	HM3	share information with other users	0.70
	HM4	share my saved CO2 emissions due to my eco-friendly behavior on the social media	0.83
F3 (0.81) Normative motives	NM1	use more public transport	0.42
	NM2	cycle more	0.70
	NM3	make healthier choices	0.65
	NM4	reduce the CO2 level and air pollution in the Copenhagen area	0.53
F4 (0.81) Technophilia	TE1	I usually like to install interesting new apps	0.86
	TE2	I regularly use apps for payments, reservations, errands etc.	0.60
	TE3	I am enthusiastic about GPS and travel apps	0.63
	TE4	I think it is exciting to try new apps	0.82
F5 (0.81) Institutional trust	IT1	I have trust in information provided by the public transport authority	0.42
	IT2	I have faith in the authorities to lead a sustainable transport vision for my city	0.61
	IT3	In the Copenhagen area, appropriate attention is given to traveler's needs	0.74
	IT4	The residents are informed about the future vision of the city	0.43
	IT5	The transport system of my city is well-organized to be sustainable	0.83
	IT6	The current transport infrastructure and policy support a sustainable future	0.85
F6 (0.74) Social trust	ST1	I can count on people in my city to travel in an environmentally sustainable manner	0.46
	ST2	I trust that Copenhageners are willing to contribute to assure a sustainable future	0.83
	ST3	I believe that environmental concerns are shared among all the residents in my city	0.64
F7 (0.72) Place attachment	PA1	Participating in transport-related test projects in my city is important to me	0.68
	PA2	Knowing more about new travel apps in my city is important to me	0.49
	PA3	Knowing more about how to make my city sustainable is important to me	0.83

Cronbach's alpha = 0.90, KMO = 0.90, Determinant of the Spearman correlations matrix = 2.17E-07

As mentioned earlier, respondents were also asked to rate the likelihood of using the app for different travel purposes. EFA was implemented to reduce the items to a smaller set of underlying summary variables. The data showed good internal consistency with Cronbach's alpha 0.87, good sampling adequacy with Kaiser-Meyer-Olkin (KMO) = 0.89, the absence of multi-collinearity, and the non-existence of identity correlations matrix. Principal axis factoring with oblique "promax" rotation generated the three factors presented in Table 3. Similar to the attitudinal variables, a cutoff value of 0.3 for item factor loading was set. The Cronbach's Alpha values for F8 and F10 were found above 0.7 reflecting good internal consistency (Miller, 1995) while it is just acceptable when it comes to F9 since it is above the "criterion-in-use" of 0.6 (Peterson, 1994).

We named factor F8 as "Active trip" versus factor F9 as "Proactive trip". The former situation seems to stimulate individuals for travel information acquisition as the response to the situation, while the latter seems to be more controlled by individuals due to e.g. lower uncertainty, not being

in rush, pre-planned trip etc. Factor F10 incorporates two items related to the situation of multi-modal trip making.

Table 3. Rotated factor matrix for variables related to travel purposes

Factor name (Cronbach α)	Acronym	Item	Factor loadings
F8 (0.82)	AT1	Spontaneous trip making	0.66
Active trip	AT2	Trips to unfamiliar places	0.70
F9 (0.69)	PT1	Receiving short notice/info about traffic disruptions (road work, accident, congestion)	0.42
Proactive trip	PT2	Long-distance trips (over 100 km)	0.57
	PT3	Wayfinding at night	0.76
F10 (0.82)	MT1	Looking for public transport schedule	0.79
Multi-modal trip	MT2	Having efficient multiple trips when switching transport mode or connection	0.68

Cronbach's alpha = 0.87, KMO = 0.89, Determinant of the Spearman correlations matrix = 0.0049

It is worth mentioning that, the factor structure extracted by EFA was then used to perform the SEM model. Based on the “two-indicator rule” characterized by Bollen (1989), the model is identified with at least two indicators per factor if the model has two or more factors. Particularly as the sample size is not small, the model is not susceptible to estimation problems (Kline, 2011)

7.2. Model estimation results

The model was estimated using the standard WLSMV estimator in M-Plus. The model comprising both structural and measurement equations fits the data reasonably well. The tested model revealed goodness-of-fit measures in terms of CFI equal to 0.926 (Browne and Cudeck, 1992) and RMSEA equal to 0.044 (Hu and Bentler, 1999). The SRMR¹ is 0.076 within the acceptable range of 0.05-0.08 (Hu and Bentler, 1999). Tables 4 through 6 show the standardized parameters estimates and critical ratios (C.R.) as the ratio of parameter estimate and standard error.

Table 4 presents the estimates of the measurement equations of the CFA that agrees with the EFA displayed in Tables 2 and 3. The aim of the EFA was to identify underlying constructs for a set of measured variables when without a priori hypotheses, whereas the CFA aimed at testing how well the data fit a priori hypothesized measurement model. When it comes to our data set, the factor structure was initially revealed by EFA and then used as part of the model structure with CFA, which improves the structural validity of the proposed model.

¹ WLSMV estimator in M-Plus does not report SRMR. We implemented the same model in R package lavaan (Rosseel, 2012), and borrowed the value of this index from the R output. Although both statistical tools provided the same model estimates, but we refer to M-Plus since it is commercial.

Table 4. Estimates of the measurement equations of the latent constructs

Factor name	Item	<i>est.</i>	<i>C.R</i>
Gain motives (F1)	reduce my travel time	1.000	-
	be on time	1.193	43.18
	pay less for daily transport	0.968	33.27
	choose my travel mode according to the departure/arrival time	1.075	37.77
	be faster and more efficient trip	1.153	42.24
	get customized information about my preferred trips	1.012	34.10
	get cost information for each suggested trip	1.05	34.26
	get pop-ups with alternative travel modes/routes, when there is disruption	0.906	29.27
	reduce time spend and difficulty for travel information search	1.081	37.64
	arrive on-time	1.177	41.62
Hedonic motives (F2)	be rewarded with bonus points for eco-friendly behavior	1.000	-
	monitor amount of calories burnt while travelling	0.798	22.64
	share information with other users	0.812	22.55
	share my saved CO2 emissions due to my eco-friendly behavior on social media	0.861	22.89
Normative motives (F3)	use more public transport	1.000	-
	cycle more	1.112	22.95
	make healthier choices	1.252	24.13
	reduce the CO2 level and air pollution in the Copenhagen area	1.279	24.76
Technophilia (F4)	I usually like to install interesting new apps	1.000	-
	I regularly use apps for payments, reservations, errands etc.	0.638	16.86
	I am enthusiastic about GPS and travel apps	0.871	25.13
	I think it is exciting to try new apps	1.102	27.37
Institutional trust (F5)	I have trust in information provided by the public transport authority	1.000	-
	I have faith in the authorities to lead a sustainable transport vision for my city	1.588	15.76
	In the Copenhagen area, appropriate attention is given to traveler's needs	1.665	15.45
	The residents are informed about the future vision of the city	1.153	13.30
	The transport system of my city is well-organized to be sustainable	1.823	15.55
	The current transport infrastructure and policy support a sustainable future	1.795	15.45
Social trust (F6)	I can count on people in my city to travel in an environmentally sustainable manner	1.000	-
	I trust that Copenhageners are willing to contribute to assure a sustainable future	1.081	23.93
	I believe that environmental concerns are shared among all the residents in my city	0.88	20.50
Place attachment (F7)	Participating in transport-related test projects in my city is important to me	1.000	-
	Knowing more about new travel apps in my city is important to me	1.283	14.16
	Knowing more about how to make my city sustainable is important to me	1.204	15.17
Active trip (F8)	Spontaneous trip making	1.000	-
	Trips to unfamiliar places	1.030	41.82
Proactive trip (F9)	Receiving short notice/info about traffic disruptions	1.000	-
	Long-distance trips (over 100 km)	1.165	20.83
	Wayfinding at night	1.154	19.97
Multi-modal trip (F10)	Looking for public transport schedule	1.000	-
	Having efficient multiple trips when switching transport mode or connection	1.064	40.07

Table 5 shows the structural equations linking the latent variables of user motives, technophilia and community context to individual characteristics.

Table 5. The linkage between individual characteristics and the user motives, technophilia and community context

Factor name	Variable	<i>est.</i>	<i>C.R.</i>
Gain motives (F1)	Male	-0.148	-2.66
	Age 30-39	-0.138	-1.53
	Age 40-49	-0.209	-2.31
	Age 50-59	-0.144	-1.54
	Car use: 2–3 times weekly	0.229	2.03
	Car travel time between 16-45 min	0.178	2.93
	Transit travel time between 30-60 min	0.162	2.66
	Travel distance less than 10 km	-0.083	-1.77
	Workplace location: Copenhagen suburb	-0.121	-1.83
	Workplace location: Copenhagen rural	-0.233	-1.87
	Information use frequency for transit travel: often and always	0.246	4.17
	Information use frequency for bike travel: often and always	-0.247	-3.48
Hedonic motives (F2)	Male	-0.215	-3.10
	Education: Bachelor	-0.156	-1.52
	Education: Master and PhD	-0.256	-2.99
	Transit use daily	-0.232	-2.22
	Travel with partner: 2–3 times weekly	0.167	1.64
Normative motives (F3)	Male	-0.173	-3.27
	Family with children	0.116	1.55
	Car use: daily	-0.169	-1.94
	Transit use: daily	-0.231	-3.04
	Transit travel time: greater than 90 min	-0.274	-2.16
Technophilia (F4)	Age 40-49	0.304	2.31
	Information use frequency for car travel: often and always	0.210	2.34
	Information use frequency for transit travel: often and always	0.341	4.51
	Information use frequency for bike travel: often and always	0.187	2.00
Institutional trust (F5)	Age 40-49	-0.106	-1.58
	Age 50-59	-0.148	-2.47
	Age 60+	-0.236	-2.98
	Education: Master and PhD	0.091	2.04
	Transit use: daily	0.155	2.87
	Bike use: daily	0.111	1.97
	Home location: Copenhagen suburb	0.073	1.93
Social trust (F6)	Age 40-49	-0.259	-2.19
	Age 50-59	-0.186	-1.77
	Age 60+	-0.275	-1.72
Place attachment (F7)	Transit use: daily	0.220	2.74
	Travel distance less than 10 km	0.070	1.66
	Information use frequency for transit travel: often and always	0.116	2.64
	Information use frequency for bike travel: often and always	0.188	3.17

Table 6 shows the structural equations according to the conceptual model. Direct effect, total effect and corresponding hypothesis are shown in the table.

Table 6. The linkage between goal-frames, community context, technophilia and use intentions

Dependent/mediator variables	Explanatory variables	Direct effect		Total effect		Supported hypothesis
		est.	C.R.	est.	C.R.	
Social trust (F6)	Institutional trust (F5)	0.918	11.891	0.918	11.891	H5
Gain motives (F1)	Place attachment (F7)	0.753	11.896	0.753	11.896	H4
	Technophilia (F4)	0.306	11.345	0.306	11.345	H3
Hedonic motives (F2)	Institutional trust (F5)	-	-	0.343	7.108	H4
	Social trust (F6)	0.374	8.582	0.374	8.582	H4
	Place attachment (F7)	1.036	12.580	1.036	12.580	H4
	Technophilia (F4)	0.215	6.378	0.215	6.378	H3
Normative motives (F3)	Institutional trust (F5)	-0.113	-1.710	0.106	1.963	H4
	Social trust (F6)	0.239	6.149	0.239	6.149	H4
	Place attachment (F7)	1.137	12.015	1.137	12.015	H4
	Technophilia (F4)	0.158	5.954	0.158	5.954	H3
Adoption intention	Institutional trust (F5)	-	-	0.028	1.817	-
	Social trust (F6)	-	-	0.063	3.797	-
	Place attachment (F7)	-	-	0.406	7.555	-
	Gain motives (F1)	0.143	3.063	0.143	3.063	H1
	Normative motives (F3)	0.263	4.760	0.263	4.760	H1
	Technophilia (F4)	0.239	7.712	0.324	10.427	H2
Active trip making (F8)	Institutional trust (F5)	-	-	0.056	3.054	-
	Social trust (F6)	-	-	0.078	4.460	-
	Place attachment (F7)	-	-	0.536	9.777	-
	Gain motives (F1)	0.264	7.151	0.338	7.413	H1
	Hedonic motives (F2)	0.120	3.215	0.120	3.215	H1
	Normative motives (F3)	-	-	0.138	4.638	H1
	Technophilia (F4)	0.129	4.488	0.405	13.136	H2
	Adoption intention	0.525	20.738	0.525	20.738	-
Proactive trip making (F9)	Institutional trust (F5)	-	-	0.088	4.737	-
	Social trust (F6)	-	-	0.106	6.110	-
	Place attachment (F7)	-	-	0.451	9.736	-
	Gain motives (F1)	0.120	3.621	0.162	4.502	H1
	Hedonic motives (F2)	0.233	7.104	0.233	7.104	H1
	Normative motives (F3)	-	-	0.077	4.381	H1
	Technophilia (F4)	0.143	5.543	0.325	11.411	H2
	Adoption intention	0.294	11.855	0.294	11.855	-
Multi-modal trip (F10)	Institutional trust (F5)	-	-	0.029	1.787	-
	Social trust (F6)	-	-	0.065	3.790	-
	Place attachment (F7)	-	-	0.579	9.416	-
	Gain motives (F1)	0.298	7.117	0.358	7.401	H1
	Normative motives (F3)	0.160	3.108	0.272	4.851	H1
	Technophilia (F4)	0.127	4.122	0.382	11.963	H2
	Adoption intention	0.426	16.470	0.426	16.470	-
Correlation patterns	Active trip - Proactive trip	0.190	12.123	-	-	-
	Active trip - Multi-modal trip	0.263	16.399	-	-	-
	Proactive trip - Multi-modal trip	0.180	11.086	-	-	-

7.2.1 The relation between goal-frames, technophilia, community trust, place attachment and individual characteristics

According to Table 5, the latent constructs are significantly related to demographics, home and work place locations, commute characteristics, travel and information use habits, indicating the relationship between the socio-technical system and individual attitudes and the values developed by using the new app.

The gain motives, i.e. the value of using the app for improving trip efficiency, are stronger for respondents who (i) are female, (ii) are young, (iii) use a car 2–3 times weekly, (iv) car traveling takes between 16–45 min, (v) transit traveling takes between 30–60 min and (vi) are frequent users of travel information sources when they travel by public transport. According to Chorus et al. (2007), public transport commuters value the usefulness of travel information to improve their daily trip efficiency because the supply-oriented nature of public transport induces a lack of knowledge about trips due to, for instance, problems related with reliability and punctuality performance. The gain motives are linked negatively to (i) shorter travel distance, (ii) the workplace being in rural and suburban areas rather than in Copenhagen, possibly due to lower perceived problems with congestion and (iii) people who use more frequently information sources for bike travel. These groups are less likely to see value in using the travel app for trip efficiency improvement.

The motives related to the game elements, i.e. hedonic motives, are positively linked to respondents who (i) are female, and (ii) travel with partner 2–3 times weekly, whereas they are negatively associated with (i) habitual daily transit users and (ii) higher educated people. Previous studies showed that social motivations for using online communication tools are stronger for female (e.g. Valkenburg and Peter, 2007; Zillien and Hargittai, 2009). Furthermore, internal motives such as perceived enjoyment, mood regulation, and pastime are more favorable for females than for males when using smartphone technologies (Chen et al., 2017). The observed difference regarding the level of education can be explained by the findings of Van Deursen et al. (2015) showing that online gaming is more appealing for lower educated people and that they use the Internet more for gaming activities than higher educated people.

The normative motives are stronger for respondents who (i) are female and (ii) have children possibly due to the need to serve as role models. They are negatively linked to (i) habitual daily car and transit users, (ii) habitual daily transit users and (iii) respondents whose transit traveling takes more than 90 min. Previous studies asserted that females are more likely to adopt environmentally-friendly travel behavior while habitual travelers are less likely to consider other alternatives and accordingly change their travel behavior (e.g., Clark et al., 2016; López-Mosquera et al., 2015; Prillwitz and Barr, 2011; Yang et al., 2013).

A technophile attitude is stronger for older adults and frequent users of travel information apps. The results of two recent user behavior studies by Velazquez et al., (2018) and Seebauer et al., (2015), on advanced traveler information system, showed that technophilia is stronger for male and younger age groups. The present study does not show any gender difference, while it with regard to age provides a different result, that needs to be explored further. However, regarding the use of travel information sources, our findings are in consistent with these two studies. Other literature findings also showed that the availability and use of information technologies (Clark et al., 2015; Goulias et al., 2004), previous positive experience with travel information and a favorable attitude toward their usefulness (Farag and Lyons, 2010; Xu et al., 2010) play an important role in individuals' affinity to such technologies and the use of ATIS.

“Institutional trust” is stronger for respondents who are: (i) younger, (ii) highly educated, (iii) habitual daily transit users, (iv) frequent daily cyclists and (v) residing in the suburbs rather than in central Copenhagen. These groups develop higher trust levels in the city’s transport-related institutions which are based on the certainty or expectation that they operate the transport systems predictably and sustainably. Ingvardson et al. (2018) found that frequent cyclists and public transport users in the city of Copenhagen are more satisfied with their travelling compared to infrequent ones. Therefore, for these two groups, their satisfaction may foster higher levels of trust in the institutions. The positive role of university education in the development of such trust is also supported by Huang et al. (2011). “Social trust” is perceived stronger for younger adults. Finally, “Place attachment” is positively linked to (i) habitual daily transit users, (ii) shorter travel distance and (iii) frequent users of travel information sources for commuting by bike and public transport. “Rejseplanen” and “I bike CPH” are two local travel apps in Copenhagen available for public transport users and cyclists, respectively. The active involvement in using local travel apps is likely to develop a greater perception of place attachment and, accordingly, promotes the participation in local community-based action.

7.2.2. The relation between the goal-frames, technophile attitude, community context and the use intention

In order to avoid a complex path diagram of the model structure, we split it into four separate diagrams presented in Figures 3 through 6. Figure 3 displays the relationship between adoption intention and situational use plus correlation pattern. Figure 4 displays the strength of the relationship between the three goal-frames, adoption intention and situational use intention. Figure 5 shows how technophilia influences goal-directed behavior and use intentions and, finally, Figure 6 displays the relationship between community trust, place attachment and goal-frames.

Figure 3. Path diagram of adoption intention and situational use intentions

As we expected, Figure 3 confirms that adoption intention relates positively to the situational use of the app, meaning that individuals with higher tendency to adopt the travel app are more likely to use it for different travel purposes.

Figure 4. Path diagram of goal-frames and use intention

As displayed in Figure 4, the model structure supported hypothesis H1 that the three distinct goal-frames relate to use intention and that their influence are situation-dependent. It suggests that acceptance and use of the VTBC-based travel app is associated not only with gain motives but also with psychological motives such as social interaction, enjoyment, normative etc. The specific results show that the gain goal-frame is positively related to adoption intention and situational use, indicating functional usefulness as the fundamental value in the use of VTBC-based travel app. In line with the goal-frame theory, trip efficiency improvement appears to be constantly activated and dominate its use. The hedonic and normative motives also frame and guide the use intention; however individuals are drawn to the corresponding motives depending on the situation/purpose. The results have important practical implications. Since gain 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. Furthermore, the value of emotional enjoyment, social interaction and green travel behavior, which is triggered by persuasive strategies, are appealing to users of VTBC-based travel apps and should therefore be emphasized in marketing materials.

Figure 5. Path diagram of technophilia, goal-frames and use intention

The model structure presented in Figure 5 confirmed hypotheses H2 and H3 that use intentions and users' goal-frames correlate positively with stronger technophilia. It suggests on the one hand that people with higher affinity to information technology perceive the values of a VTBC-based travel app as more important, and on the other hand, are more likely to use the app, clearly characterizing technophiles as the early adoption target group for the introduction of this new generation of travel information systems into the market. This result is in line with the argument of Edison and Geissler (2003) that 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".

Figure 6. Path diagram of trust, place attachment and goal-directed behavior

According to Figure 6, the model results also confirmed hypotheses H4 (i.e. indirect effect of community trust and place attachment on use intentions) and H5 (i.e. the causal effect of institutional trust on social trust).

“Institutional trust” is positively linked to “social trust”; in line with institutional performance theories suggesting trust appears “from the top down” saying that “it is effective government that enables social trust and association membership to appear.... good government is the most essential feature for generating citizen trust and a civil society capable of supporting civic participation” (Allum et al., 2010).

“Institutional trust” is negatively associated with the normative goal-frame. Individuals with higher trust in institutions appear to perceive less important the value of the travel information system to promote environmentally-friendly travel behavior. They are less concerned with sustainability-oriented mobility behavior that the system adoption is envisioned to foster in the city. The negative correlation between trust and pro-environmental behavior where collective action is needed is also reported by recent studies (e.g., Carattini et al., 2015; Volland, 2017). Diffusion of responsibility effect (Darley and Latane, 1968) could be considered as one explanation for this finding. Diffusion of responsibility can happen in multiple actor environments when each actor may believe that others are either responsible for taking action or have already done so. In our study, individuals with higher trust feel less responsible for making their own contribution since they may believe that the institutions/organizations are potentially responsible for developing the city in a sustainable manner. There is little pressure on them to take action as they neglect their own extra involvement and responsibility. According to Leary and Forsyth (1987), they may rely extensively on experts (e.g., transport planners) or leaders (e.g., transport policy makers) and accordingly, the feeling of responsibility diffuses to them. Previous literature provided empirical evidence for this effect on environmental behavior in relation to pro-social behavior (e.g., Anker and Feeley, 2011; Santarius and Soland, 2018; Soland, 2013).

People with stronger social trust perceive the hedonic and normative goal-frames as important drivers for their attraction and engagement. Collective efficacy as a social identity appears to be related to a sense of collaborative engagement by the formations of goals intended to satisfy higher order needs such as sense of belonging, social approval and environmentally-friendly travel promotion.

According to Table 6, the total effects of the two forms of trust on the use intention are positive. Individuals with more social trust may be more prone to pursue the common good of society, which promotes participation in collective actions. It is mainly due to the fact that they tend to believe other members will also be concerned with and collaborate to protect the common good (Stern and Baird, 2015). Likewise, when collaborative efforts are needed, people with greater levels of institutional trust are more prone to behave in a responsible manner. In that, they are inclined to rely on the credibility of public institution enacting and implementing necessary policies in a reliable manner (Jones, 2010; Jones et al., 2009).

Higher “Place attachment” relates positively to the three distinct goal-frames, suggesting that individuals with a higher feeling of place attachment attach more value and importance to the functional, social, hedonic and environmental attributes of the new travel app. For this group, their affective bonds with the city develop a positive evaluation of the benefits of the travel information system to improve the city's quality of life. Furthermore, its total effects on the use intention are relatively high indicating the importance of the positive emotional bond to drive the user behavior.

The social dynamic behind the system and its influence on users’ attitude and behavior indicate the importance of public engagement to achieve the goals of the system implementation. Luederitz et al. (2015) view urban areas as human environment systems in which participation is an important constituent to ensure sustainable urban design and planning. Banister (2008) argues that public participation in sustainable mobility planning contributes to promoting socially responsible behavior in a more effective way since it could develop sustainable values and facilitate the desired attitude and behavior change among citizens. Furthermore, public acceptability of sustainable solutions such as ATIS could be triggered by public engagement. The public must be engaged at the start instead of toward the end of the planning process i.e. a shift from “design-defend-implement” to “discuss-design-implement”(Bickerstaff et al., 2002; Leyden et al., 2017). In the transportation field, a number of systematic frameworks to embed public engagement established by previous studies (e.g., Banister, 2008; Bickerstaff et al., 2002; Cascetta et al., 2015; de Luca, 2014; O’Faircheallaigh, 2010)

In summary, our results suggest that there is an association among technophile attitude, users’ motives, trust, place attachment and use intention of VTBC-based travel apps. Stronger technophile attitude influences both user motives and use intentions positively. Behavioral intention to use the travel app is positively affected by functional and psychological motives; however their effects are situation-based.

8. Policy implications

The findings of this study have several implications for policy and practice to foster users’ attraction and engagement toward VTBC-based travel apps due to the diversity of influential factors identified and the different levels at which they operate.

The findings show the importance of higher-order needs in influencing the adoption intention toward mobility-management travel apps. The satisfaction of non-monetary aspects of enjoyment, social self-development and environmentally-friendly travel promotion motivates individuals to use the app. Encouraging their development in relation to persuasive mobility tools may result in successful users’ attraction and engagement. Self-monitoring, information sharing and gamification elements (i.e. incentives and rewards) appear to be considered as appealing persuasive strategies promoting and driving engagement, which should therefore be stressed throughout the process of system development, business design and marketing. Furthermore, policies that provide sufficient knowledge about environmental issues and engender a sense of responsibility are effective to draw public attention to the prominence of their engagement for environmental and social benefits.

According to a recent literature review by Hermesen et al. (2016), self-monitoring by delivering feedback through digital technology is “an effective way to disrupt habits, regardless of target behavior”. They also stressed the important role of information presentation in the effectiveness of a feedback intervention. In the context of mobility, two studies showed that the effect of CO2 emissions information on individuals’ behavior/attitude change is different depending on the presentation format, e.g., negative framing vs. positive framing (Avineri and Waygood, 2013) and quantitative vs. visual (Brazil et al., 2013). Therefore, integrating factors having contextual effects in the design of mobility-management travel apps could be considered as relevant techniques to increase their efficacy for supporting sustainable travel behavior.

Our findings show that the use of gamification and incentives in VTBC-based travel apps can motivate travel behavior change. It is also confirmed by Bowden and Hellen (2019); however, they argue that giving rewards to relevant user profiles and situational contexts is more important since the tailoring of the intervention prompts real mode shift, as well as maintain and increase sustainable and active travel. As suggested by Forbes et al. (2014), segmentation-based techniques for user profiling can be employed to determine which user groups are most prone to be influenced by which intervention components.

The results of this study highlight the domination of self-interest motives of trip efficiency improvement for the adoption intention. Given the revealed insights into the interaction mechanisms of the persuasive solutions with travel behavior, the focus might need to shift from simply reducing/replacing car travel demands by means of mobility-management travel apps toward analyzing how this technology can improve individuals’ trip efficiency by, for instance, providing accurate, informative and reliable travel information. Therefore, exploiting the potential of persuasive mobility-management solutions for trip efficiency improvement might be more promising in the pursuit of sustainable transport planning as well as the development of mobility as a service (Maas).

The findings show that technophiles are an important early adoption target group of VBTC-based travel apps. Nevertheless, the system attributes and functionalities should be designed aligned to the needs of both groups of technophiles and technophobes in order to increase its penetration rate. As suggested by Seebauer et al., (2015), on the one hand, the entry threshold for unwilling users should be lowered (e.g. by easy and understandable feature design) and on the other hand, the app should appeal to tech-lovers (e.g. by providing the possibility of participatory design and crowd sourcing).

Our findings also suggest the importance of social dynamic behind the information system, captured by trust-based community and place attachment, in influencing users’ attitude and behavior. It indicates that public engagement is important in ensuring the success of the system implementation. It is essential to develop a meaningful dialogue between decision makers and the public to ensure its public acceptance. The public dialogue should be based on – and accompanied by – a robust communication strategy to understand citizens’ travel needs and expectations, clarify the need for change in their travel behavior and highlight the importance of their contribution.

Finally, this study presents that users could exhibit different behaviors according to socio-economic characteristics, travel habits, attitudinal factors etc. Therefore, it is important to appreciate that “one-fit-all” actions without considering such heterogeneity might fail to address the diversity of behavioral responses, and accordingly cause inefficiency in policy. This study provides a good understanding of different user groups, which aspects of the technology they value and their corresponding motivations and barriers for their attraction and engagement. Therefore, for authorities and system developers, it is recommended to account for specific groups of users, understand their needs and expectations, and provide an appealing design from a user’s perspective, since it will lead to motivating sustainable travel behavior. There is a wide agreement that tailoring the travel solutions is fundamental for the design, implementation and dissemination of mobility-management travel apps aimed at encouraging VTBC (Andersson et al., 2018; Dickinson et al., 2015; Gabrielli et al., 2014; Kramers, 2014; Meloni and Teulada, 2015).

9. Limitations and future direction

While our study provides important insights, the evaluation of the study in light of its limitations is noteworthy.

Firstly, this study did not include a population representative sample which is mainly related to the data collection and distribution method. Data collection through online survey restricts the target population to a pool of Internet users as respondents. Future study needs to address this issue by incorporating other methods such as telephone or face-to-face interviews.

Secondly, the data for this study were collected from Danish travelers. It would be useful to replicate this study using other countries’ travelers in order to better attain the robustness of the results. It is recommended to examine the hypothesized relations in cross-cultural settings. This would improve the current understanding of VTBC-based travel app adoption in a multicultural context owing to possible cultural differences in perceptions.

Thirdly, during the survey administration, the new travel app was not yet deployed. Hence, the focus of this study was on the phase of before adoption. Additional research is required to employ a longitude design to investigate post-adoption behavior. It is essential to appraise the long-term effects of such technologies on travel behavior modification.

Lastly, there is some evidence showing that using mobile ICT devices while travelling creates a negative effect against sustainable mobility behavior. Julsrud and Denstadli (2017) showed that active users of smart devices are more likely to develop negative attitudes to public transport. Furthermore, the amount of time spent on the usage of ICT may induce more motorized travel demand, including by car (Hong and Thakuriah, 2016). We encourage future research to investigate such negative effects in relation to mobility-management travel apps.

10. Conclusion

The motivation for this study reflects the evolving needs of encouraging sustainable urban mobility and the development of persuasive technologies, as well as from questions and gaps revealed from the literature in travel information and user behavior. We identified a lack of knowledge about how

individuals are motivated to accept and adopt VTBC-based travel apps, as well as the challenges related to user attraction.

This study provides empirical evidence that user attraction and engagement are associated with the travel app ability to satisfy functional and psychological human needs. The results show that the use intention of the VTBC-based travel app is not exclusively guided by their functional utility for improving trip efficiency. It also depends on their ability to satisfy emotional needs (i.e. by triggering feelings of enjoyment, sense of belonging and social identification) as well as develop normative values.

The specific results show that the higher level of gain motives was related to the higher level of the use intentions, i.e. both adoption intention and situational use, whereas when it comes to hedonic and normative motives, this positive relation is conditional on travel purpose. Therefore, the loyal users of the app could be characterized by being functionally motivated which underlines the importance of the functional values of the system to attract and engage future users.

The results also show that technophiles are an important target group of VBTC-based travel apps. They can play a significant role in promoting the use of this new generation of travel information systems, thus contributing to a rapid increase in demand. The results support that community trust and place attachment influence users' attitude and behavior, indicating the importance of public engagement in ensuring the success of the system implementation.

As described in the policy implications section, the study provides authorities and app designers with an understanding of different user groups and useful tools for effective and efficient app design.

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Conflicts of interest statement

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

Appendices

Appendix A

Table A.1 shows the complete rotated factor matrix for attitudinal items obtained by EFA. The acronym of indicators is in accordance with the items described in Tables 2 and 3.

Table A.1. Complete rotated factor matrix

		Factors						
Factor name	Acronym	F1	F2	F3	F4	F5	F6	F7
Gain motives	GM1	0.72	-0.06	0.12	0.07	-0.02	0.09	-0.20
	GM2	0.83	-0.17	0.15	0.02	-0.04	0.09	-0.08
	GM3	0.56	0.05	0.25	0.00	0.00	-0.06	-0.09
	GM4	0.75	-0.04	0.13	-0.06	0.00	0.02	-0.03
	GM5	0.80	-0.12	0.13	0.07	0.00	0.04	-0.09
	GM6	0.77	0.10	-0.21	-0.01	0.06	-0.04	0.08
	GM7	0.71	0.11	-0.01	-0.03	0.07	-0.10	0.03
	GM8	0.67	0.16	-0.22	-0.06	0.01	-0.06	0.09
	GM9	0.80	-0.10	-0.02	-0.04	-0.07	0.01	0.13
	GM10	0.89	-0.10	-0.05	-0.02	-0.06	0.09	0.01
Hedonic motives	HM1	0.08	0.42	0.26	-0.07	-0.03	-0.01	0.18
	HM2	-0.10	0.65	0.18	0.02	-0.01	0.04	-0.03
	HM3	0.07	0.70	-0.08	0.08	0.00	-0.01	-0.07
	HM4	-0.12	0.83	0.07	-0.01	-0.03	0.01	-0.07
Normative motives	NM1	0.28	0.03	0.42	0.00	0.06	-0.03	-0.04
	NM2	0.05	0.01	0.70	0.04	0.06	-0.08	0.03
	NM3	0.03	0.15	0.65	0.04	-0.02	0.03	0.13
	NM4	0.15	0.13	0.53	-0.06	-0.04	0.05	0.19
Technophilia	TE1	-0.03	-0.02	0.05	0.86	0.05	-0.03	-0.03
	TE2	-0.07	0.00	0.00	0.60	-0.07	0.04	-0.02
	TE3	0.08	0.06	0.00	0.63	0.00	0.00	-0.03
	TE4	-0.02	0.03	0.02	0.82	0.00	-0.04	0.07
Institutional trust	IT1	0.04	-0.10	0.06	0.10	0.42	-0.04	0.04
	IT2	0.00	-0.01	0.00	0.06	0.61	0.13	0.02
	IT3	0.01	0.00	0.02	-0.02	0.74	0.05	-0.09
	IT4	-0.07	-0.01	-0.02	-0.01	0.43	0.05	0.14
	IT5	-0.04	0.02	0.03	-0.08	0.83	-0.09	-0.03
	IT6	0.00	0.04	-0.01	-0.12	0.85	-0.11	-0.04
Social trust	ST1	0.02	0.18	-0.09	-0.01	0.28	0.46	-0.14
	ST2	0.11	-0.04	-0.03	-0.01	0.03	0.83	0.02
	ST3	-0.04	0.01	-0.02	0.00	-0.04	0.64	0.15
Place attachment	PA1	-0.08	-0.04	0.07	0.02	0.10	0.00	0.68
	PA2	0.16	0.08	-0.11	0.21	0.00	-0.02	0.49
	PA3	-0.08	-0.11	0.18	-0.11	-0.09	0.11	0.83
		Factors						
Factor name	Acronym				F8	F9	F10	
Active trip	AT1				0.66	0.15	0.03	
	AT2				0.70	0.01	0.20	
Proactive trip	PT1				0.16	0.42	-0.03	
	PT2				0.14	0.57	0.05	
	PT3				-0.08	0.76	0.06	
Multi-modal trip	MT1				0.12	-0.07	0.79	
	MT2				-0.02	0.23	0.68	

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

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