Participating in environmental loyalty program with a real-time multimodal travel app: User needs, environmental and privacy motivators

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2. Participating in Environmental Loyalty Program with a Real-time Multimodal Travel App: User Needs, Environmental and Privacy Motivators

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ABSTRACT

The increasing complexity and demand of transport services strains transportation systems especially in urban areas with limited possibilities for building new infrastructure. The solution to this challenge requires changes of travel behavior. One of the proposed means to induce such change is multimodal travel apps. However, understanding the motivators underlying individuals' travel intentions is essential to design and evaluate their effectiveness. This paper pinpoints and analyses the drivers and barriers that influence individual travel decisions when using such apps. The analytical framework relies on Alderfer's ERG model of human needs that relate the individual's intentions to three domains, namely (1) Existence, (2) Relatedness and (3) Growth needs. Furthermore, environmental attitude, information privacy concerns and perceived difficulties when using the system are incorporated as to better explain user-sided heterogeneity. The case-study focuses on a new travel information system in Copenhagen (Denmark), which is not yet operational, through a technology-use preference survey among 828 travelers. Structural equation models revealed that the motivation for choices are specific to individual users and depend on wide-ranging factors that go beyond traditional economic and socio-demographic methods. The study revealed (1) different intentions among individuals according to the perceived value of the new information system, (2) a relation between different environmental attitude constructs and users' needs, (3) a stronger appeal to use the system for individuals with higher needs of developing social self-concept and eco-travel self-efficacy as well as with lower perceived privacy risk and perceived difficulties, (4) that both functional and psychological factors affect adoption intention.

Keywords: Travel app; Behavior change; Travel information; Persuasive technology; Need theory

2.1. Introduction

Transportation contributes 19% to global energy use and 23% to CO2 emissions related to energy consumption (IEA, 2014). Furthermore, urban mobility alone generates "40% of all CO2 emissions of road transport and up to 70% of other pollutants from transport" (EEA, 2017). Apart from the environmental issues, the continuous growth of mobility demand in modern cities increases traffic and affects the performance of transportation systems negatively. Given the current pattern of urban mobility, the environmental and transport-related issues will be aggravated, and therefore a concerted effort is needed to promote more sustainable mobility behavior and persuade individuals to change travel behavior in favor of environmentally friendly alternatives.

In order to promote sustainable mobility behavior, voluntary travel behavior change programs (VTBC) have been introduced aiming at nudging travelers toward sustainable modes of transportation. In this context, the use of advanced traveler information systems (ATIS) for improving mobility management in urban areas has received a lot of attention. ATIS have the potential to improve travel experience, enhance personal mobility and productivity of transportation since they allow travelers to make better informed travel decisions. ATIS assisted VTBC, such as ones tailored for and integrated in mobile applications, offer opportunities to raise travelers' awareness about their mode choices, travel pattern and the consequences of their mobility behavior such as travel time/energy saving, personal CO2 emission footprint, etc. These information technologies, besides their low-cost to decision makers and wide availability to the general public, are potentially powerful from the behavioral perspective. Problem awareness when giving 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, VTBC-based information technologies are important tools in affecting travelers' decisions and guiding them toward sustainable travel behavior.

This paper describes a study of the intention to use a real-time multi-modal smartphone app aimed at motivating travel behavior change in the Greater Copenhagen Region (Denmark) toward promoting sustainable transport options. 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 (Andersson et al., 2018; Arnott et al., 2014; Webb et al., 2010). However, a recent literature review by Sunio and Schmöcker (2017) revealed a lack of sufficient attention to explaining the users' behavior of mobility-management travel apps with support in behavioral theories.

This study focuses on exploring the motivation to use a new real-time multi-modal travel app for Copenhagen as ATIS for digital mobility-management assistance. The proposed app, which is not yet operational, integrates the elements suggested by Kramers (2014) for the next generation ATIS. The new VTBC-based travel app is a multi-faceted mobile app including both travel information and persuasive strategies 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 this new generation of travel apps, a critical mass is essential for market penetration and use (see. Regulatory travel demand management policy measures are based on imposing travel costs or restrictions as external behavioral motivators. In contrast, the effectiveness of digital mobility management assistance as a voluntary tool for promoting sustainable transport is driven mostly by the user's need-based internal mechanisms of behavior. Meloni and Teulada (2015) describe three behavioral change elements that may induce target behavior through the use of ATIS: motivation, ability and triggers for behavioral change.

This study aims to explore these aspects through the lens of psychology and social science. In that, 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, to reduce the transportation footprint in terms of air pollution and climate change and to enhance the quality of life through the reduction of commuting stress and promoting health through physical activity. The magnitude of the impact of ATIS on regions, cities and urban networks greatly depends on adoption diffusion and long-term engagement of users. Noticeably, this process is not distinctly technological, but has a social dimension that, forces a socio-technical evaluation, i.e. considering individuals' interaction with technology as well as other individuals in the process of study and design (Dickinson et al., 2015).

This study addresses the socio-technical perspective of ATIS adoption by offering to explore the underlying mechanisms of VTBC-based travel app users' behavior developed from Alderfer's (1969) Existence-Relatedness-Growth (ERG) theory of human needs. As 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 the ethical and normative issues that usually impede the 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).

The rest of the paper is structured as follows: Section 2.2 starts with literature review of VTBC- based travel information systems. Section 2.3 presents and discusses the motivational factors and barriers to adopt the new system and relevant literature review to support the proposed theoretical framework and corresponding hypotheses. Section 2.4 presents the mathematical method (i.e. Structural Equation Modelling) for testing the hypotheses. Section 2.5 and 2.6 introduces the case study, survey design, data collection as well as sample descriptions. Section 2.7 presents the results and discussions. Limitation and future direction is resented in Section 2.8 and finally, Section 2.9 concludes the paper.

2.2. Literature review

Most of the research regarding information technologies concerns their prospective impact. Chorus et al. (2006) and Ben-Elia and Avineri (2015) provide two comprehensive reviews regarding the potential of travel information to induce behavioral change and the behavioral mechanism of information acquisition and use. Chorus et al. (2006) provide insights on the magnitude of the effect, the contextual circumstances under which information use is effective, the impact of providing information on the chosen versus non-chosen alternatives, the type of travelers and trips that are more prone to information use, and the effect of information reliability and system familiarity. Ben-Elia and Avineri (2015) review the type of information used (i.e., descriptive, experiential, and prescriptive), the psychological heuristics that are related to information acquisition, and the effectiveness of information in changing travel behavior. In contrast, research on the effect of VTBC is scarcer. The rapid increase in information communication technologies (ICT) such as mobile phones and internet, has paved the way for promoting sustainable travel behavior through a better travel information provision (Ben-Elia and Shiftan, 2013). Taylor and Ampt (2003) reviewed the implementation of two mobility-management tools named Travel-Blending and IndiMark, applied in Adelaide, Brisbane and Perth, respectively. Large-scale field experiments proved that among participants, mobility-management tools are useful to significantly reduce car mileage, increase public transport ridership and to a lesser extent encourage cycling. Recent field experiments of a mobility-management program, the Quantified Traveler, shows similar prospects with respect to travel behavior change. The Quantified Traveler has a computer-based platform for travel diary collection and feedback; it still relies much on human assisted travel tailoring (i.e., Jariyasunant et al., 2015). The study by Mulley and Ma (2018) evaluated the long-term effects of a community based VTBC program, namely TravelSmart implemented in Adelaide, South Australia. Analyzing 3-year panel data collected by GPS tracking and survey method supported the effects of TravelSmart on reducing the amount of car driving in terms of both time and distance. Furthermore, the effects were found to be sustained over time. Froehlich et al. (2009) reveal that willingness to engage in eco-friendly travel is also independently sought regardless of VTBC programs, even in the U.S., a highly car-oriented country. In their survey, 13% of the respondents combined travel with exercise, 61% had taken at least one action with a direct goal of eco-friendly travel, including reducing car travel, using more fuel efficient cars, trip chaining and walking. Hence, VTBC address a potentially larger market demand for travel behavior change.

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. 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 (i.e., carbon emission scores, interaction with social networks, and loyalty points that can be redeemed for rewards) (see e.g., Brazil et al., 2013; Brazil and Caulfield, 2013; Wilhelms et al., 2017; Yujuico, 2015). Replacing human interaction with ATIS digital schemes are currently under

development offering, among other things, opportunities for communication and collaboration across users, information sharing and social networking (e.g., Ferreira et al., 2017; Kramers, 2014; Meloni and Teulada, 2015; Pronello et al., 2016). 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 in influencing users to change their travel behavior in favor of green or sustainable travel (Andersson et al., 2018; Castellanos, 2016; Coombes and Jones, 2016; Khoo and Asitha, 2016; Nakashima et al., 2017; Poslad et al., 2015).

Andersson et al. (2018) performed a literature review on how smartphone applications are effective in supporting behavior change in the domains of energy and climate, health and transport. The results suggest that user customization, relevant and contextualized information and feedback, commitment, and appealing design are significant facets to encourage behavior change. Castellanos (2016) investigated the effects of financial incentives delivered through mobile phones to promote modal shift toward environmentally friendly modes of transportation. The results of the field study showed that users' extrinsic and intrinsic motivation for behavioral change, as well as tailoring mobile applications that support individual needs and expectations, are important to modify traveler behavior. Coombes and Jones (2016) explored the use of a tracking technology with a reward scheme, "Beat the Street", for encouraging active travel in children through a quasi-experimental study. They found that gamification could increase engagement and possibly promote active travel modes in the short term. However, its long term effect to change and maintain the desired behavior is an important issue for information communication technologies (ICT). Through a stated preference survey, Khoo and Asitha (2016) showed that real time traffic information is one of the most required features of smart phone traffic information apps which furthers their adoption. They found that individual preferences regarding the app features are very important with a view to developing more efficient transport practices since it enables an increase in the users' compliance with the delivered information (e.g. diverting to alternative routes). Nakashima et al. (2017) investigated the effect of a smartphone app with the function of gamification including scoring, ranking and competition in changing travel behavior (i.e. increasing number of steps) through a before-after study design. The results revealed that the effectiveness of the developed app in changing behavior depends on users' current walking behavior as well as their personality. More specifically, this is effective for people who do not usually walk too much and particularly for people who have a competitive personality. Poslad et al. (2015) studied the impact of different travel incentives (i.e. traveler mobility pattern, targets and challenges, loyalty points and social networks) through the use of the Tripzoom app on motivating 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. However, providing users with customized information, feedback and goals aligned with their specific needs were found essential to trigger behavior change. Additionally, an appealing and simple design appeared to be important to the users.

2.3. Theoretical framework

Tailoring the travel solutions to support individual needs and expectations can possibly lead to a powerful potential travel shift toward eco-friendly solutions. There is wide agreement that satisfying user needs is fundamental for the design, implementation and dissemination of mobility-management travel apps aimed at encouraging VTBC (Andersson et al., 2018; Gabrielli et al., 2014; Grotenhuis et al., 2007; Meloni and Teulada, 2015; Wang et al., 2016). This study contributes to the body-of-knowledge by exploring Alderfer's (1969) ERG (Existence, Relatedness and Growth) theory as a motivator for the intentions to use mobility-management travel apps. The ERG theory, which evolved from Maslow (1943)'s theory of human motivation and received greater empirical support, 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). While the concept of needs is long-standing in empirical psychology for studying motivation, with the shift toward cognitive theories this concept was largely replaced by goal-related efficacy formulated as functional utility (Deci and Ryan, 2000).

The self-determination theory (SDT) revisits the need-based approach due to the understanding that intrinsic motivation to satisfy higher-order emotional needs of relatedness and growth (i.e., autonomy and competence) is an important part of goal-directed behavior (Deci and Ryan, 2000). Because the SDT largely focuses only on satisfying emotional needs as intrinsic motivation for goal-directed behavior, the current study extends the SDT model to represent functional, relatedness and growth needs. Andersson et al. (2018) used a theoretical framework including the Theory of planned Behavior (TPB), the Transtheoretical Model (TTM), Diffusion of Innovations (DI), and the concept of Gamification for explaining important factors in constructing a behavior change support system (BCSS) for smartphone applications. This study follows the same line of research as Pronello et al. (2017) who investigated the intentions to use the "Optimod'Lyon" multi-modal travel app by applying the TPB. The two theories, the TPB and the ERG theory of needs are linked through the notion of decision factors originating from personal identity and situational concerns. Personal identity could be studied using the theory of human needs, where the satisfaction of needs motivates individuals to engage in action (Woodbine and Liu, 2010) and the two theories can also be viewed as complementary (Gucciardi and Jackson, 2015). While simple navigation apps are mostly driven by their functional value, the general mobile app use and adoption is driven by a wide range of psychological needs: functional, social, self-esteem and self-actualization needs (Kim and Baek, 2018; Sun et al., 2017). Hence, as recommended by Dickinson et al. (2015) this study identifies functional and psychological user needs as backbone for user attraction and engagement.

The widely used theories in innovation adoption behavior such as the TAM and TPB focus more on individuals' perceived drivers to use innovations while the factors leading to consumer resistance are disregarded. Innovation resistance studies argue that it is even more important to comprehend innovation driven reasons against adoption. Previous research implies that innovation barriers can form negative attitudes toward them which can then delay or impede consumer adoption (Antioco and

Kleijnen, 2010; Joachim et al., 2018; Kleijnen et al., 2009; Laukkanen et al., 2008). Moreover, a recent study shows that the influence of barriers on adoption intention is almost twice as strong as those of adoption factors (Claudy et al., 2015), underscoring the necessity of addressing the barrier effects.

As proposed by Ram and Sheth (1989), the barriers could be categorized into functional and psychological. Two of them are the usage barrier and the risk barrier that we investigate in this study. The usage barrier is associated with perceived usefulness or ease of use while the risk barrier is related to perceived risk. In the context of VTBC-based travel app adoption, the usage barrier may be relevant to the issues of e.g. complexity of the idea and use, time-consuming, and unsatisfied expectations about the gamification elements (i.e. incentives and rewards). The risk barrier for instance relates to the privacy and security concerns of the app users for online activities. With ICT advancement, concerns about data privacy and its impacts have arisen. The concerns mainly related to improper information collection, storage, protection from disclosure to unauthorized persons and use the information for unintended purposes without their permission (Hong and Thong, 2013). This has motivated researchers to investigate extensively the information privacy in online environmet. In the context of E-commerce, there is wide agreement that information privacy concerns influence individuals' attitude toward online services and acceptance (e.g., Bergström, 2015; Fortes and Rita, 2016; Kim et al., 2011). Previous literature has examined users' perceived concerns of leaking of personal information when they share their activities on social media (Chang and Heo, 2014; Christofides et al., 2009; Fortes and Rita, 2016; Lemay et al., 2017; Taddicken, 2014; Waters and Ackerman, 2011). Little connection was found between the intention of self-disclosure and the concern of privacy invasion (Christofides et al., 2009; Lemay et al., 2017). People ignore privacy risks when exhibiting their activities on social media, particularly when they trust them (Waters and Ackerman, 2011), since they are under the impression that such information is only accessible within the network that they developed (Taddicken, 2014). When it comes to mobile applications, however, the negative effect of privacy concerns on download and use intention was reported by prior literature (e.g., Gu et al., 2017; Shklovski et al., 2014). Our study investigates the barrier effects as reasons against adoption of VTBC-based travel apps along with the reasons for their adoption, captured by functional and emotional perceived benefits. As the barriers represent perceived behavioral control, they supplement the ERG theory.

Individual's engagement in actions may not only rest on weighing the expected costs and benefits but the desire to act appropriately or morally. Therefore, moral and normative considerations also guide individual behavior and action. People may engage in environmental conservation or preservation activities due to the benefits to others or the environment, instead of appealing to self-interest even if these actions involve some costs and efforts (Czajkowski et al., 2014; Steg et al., 2014). In the context of mobility, various studies supported that environmental attitude and concern exert some influences on travel behavior. Nilsson and Küller (2000) showed that environmental attitudes are positively associated with people's willingness to reduce car usage or to support car travel reduction measures. Vredin Johansson et al. (2006) found that attitudes toward being pro-environmentally inclined influence the choice of an environmentally friendly mode (i.e. train) over a less environmentally friendly mode (i.e.

bus). Clark et al. (2016) presented that willingness for environmental protection precedes a change in travel behavior toward non-car and active commuting. Kim et al. (2017) found that people's intention to use a shared car is significantly influenced by a pro-environmental attitude. Bouscasse et al. (2018) showed that people with high environmental concern have favorable attitudes toward the use of public transport (i.e. easy, useful and pleasurable) compared to those who do not have such environmental motivation. Furthermore, environmental concern influences public transport habits positively and car use habits negatively.

Since the use of VTBC-based travel apps is likely to embrace the aspects of social responsibility and personal morality, our study also integrates environmental attitude in order to enhance our understanding of a wider set of motivators governing the user attraction and engagement. As suggested by Ajzen and Fishbein (1980) as well as Bamberg (2003), environmental attitude as a general attitude does not have a direct effect on specific behaviors, but it is indirectly determinant through situation-specific beliefs and attitude. Hence, our study investigates the effect of environmental attitude on individual intention to use a VTBC-based travel app mediated by its perceived values. Figure 2-1 describes the conceptual behavioral framework. Based on the above literature support, the hypothesis related to the model in this study is proposed as follows:

H1: Satisfying functional and psychological user needs relates positively to adoption intention
H2: Stronger perceived usage difficulties relates negatively to adoption intention
H3: Stronger information privacy concern relates negatively to adoption intention
H4: Environmental attitude has an effect on adoption intention, mediated by user's functional and psychological needs

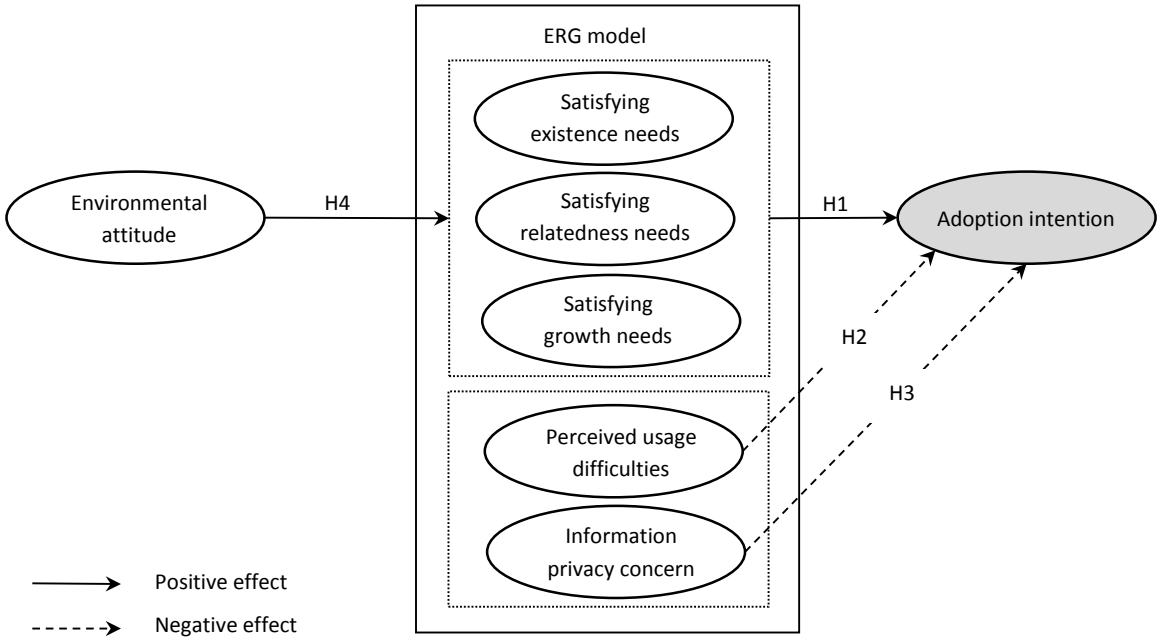

Figure 2-1 Conceptual model on motivations to use the app

2.4. Behavioral 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). The SEM foundation lies in two multivariate techniques: confirmatory factor analysis (CFA) and multiple regressions, also called path analysis, which test measurement and structural equations simultaneously. The measurement equations represent relations between latent constructs and their respective indicators while structural equations represent the directional relations between latent constructs. The methodology is comprehensively described by Pugesek et al. (2003). An increasing number of recent studies employed SEM to examine the use of travel mobile apps (Assemi et al., 2018; Fang et al., 2017; Im and Hancer, 2017; Lu et al., 2015; No and Kim, 2014; Weng et al., 2017).

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

$$I_{rn} = Z^*_{ln}\,\alpha_r + \upsilon_{rn} \quad \text{and} \quad \upsilon_{rn} \sim N(0, \Sigma_\upsilon) \quad \text{for} \quad r = 1, \dots, R \tag{1}$$

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

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

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

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 υ_{rn} which is a vector following a normal distribution with covariance matrix Σ_υ. 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., environmental attitude) with the mediator latent constructs Z^*_l (e.g. the three groups of needs) 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 levels of using the app by respondent *n* (i.e. in 1-5 Likert scale from highly unlikely to highly likely). The error terms is presented as ξ_n.

The commercial software M-Plus was used to estimate the parameters of the model (Muthén and Muthén, 2012). The parameters of the four sets of equations were estimated simultaneously by using Maximum Likelihood with Huber-White covariance adjustment (Yuan and Bentler, 2000). Standard errors were computed using the White's sandwich estimator which provides robust statistics to the non-normality of the indicators as well as the categorical variables (White, 1980). 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). CFI index compares the estimated model with an independent, or null, model. RMSEA index specifies to what extent the observed covariance matrix and the hypothesized covariance model are different. SRMR is an index of the average of standardized residuals between the sample covariance matrix and the hypothesized covariance model. A cut-off value for CFI greater than or equal to 0.90 and RMSEA smaller than 0.05 represent good fit. A RMSEA value falling between the range of 0.05 and 0.08 is the indicator of accepted fit. A SRMR value smaller than 0.05 is the indicator of good fit while a value between 0.05 and 0.08 indicates accepted fit (Hu and Bentler, 1999; Kline, 2011).

2.5. Case study

A new advanced real-time multimodal travel app is under investigation for Copenhagen traffic management enhancement. The idea behind the system is to integrate traffic information and journey planning to include all modes of transport. It includes multi-modal real-time information, multi-criteria route planning on the basis of time and cost, multi-modal choice combinations, ridesharing opportunities and easy payment. In order to induce behavioral change, persuasive strategies are also considered by the system designers. For more information, see PPI ITS Project, (2014). Persuasive Technology (Fogg, 1998, 2003), which is an inspiration for more researchers in this field, has focused on system design explicitly attempting “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. The persuasive technologies monitor human activities in relation to resource usage, and provide information to the user for the purpose of motivating behavioral change (Brynjarsdottir et al., 2012). Challenges & goal setting, self-monitoring, social networking & comparison, gamification and rewards are among the main strategies adapted to design persuasive technologies.

The new 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. It is also possible to monitor CO2 savings and calorie consumption over time. Moreover, the app enables its users to register for an environmental-friendly loyalty program: the more an environmental-friendly itinerary they take, 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. On the level of design, therefore, the travel app has been considered to consist of health and environmental feedback, tailoring travel options, self-monitoring, tunneling users toward green behavior, social networking, nudging and gamification elements. In this respect it is fairly similar to other mobile apps currently under development: Ubigreen, MatkaHupi, Peacox, SuperHub, Tripzoom and IPET (Meloni and Teulada, 2015). However, as a hypothetical scenario in this study, the persuasive features of the app are only accessible, if the users create a personal account; hereafter “GREEN account”, provides the system with some personal information, and allows the system to record their travel behavior. Without having “GREEN account” activated, the app serves as a typical travel app. It is important to note that, the

GREEN option, in this format, is not part of the initial app design. We formulated the “GREEN account” in order to investigate the users’ behavior regarding the persuasive features in a more appropriate manner and accordingly, address the research objectives.

2.6. Method and materials

A tailor-made web-based questionnaire was designed according to the developed behavioral framework. At the beginning of the questionnaire, participants were supported with information related to the functionalities and features of the new travel app such as multimodal travel information, incorporated persuasive strategies, the need for creating “GREEN account” to access the persuasive attributes, the policy of monitoring their travel behavior etc. The survey elicited the following information; (1) the likelihood of using the app through “GREEN account” measured on a 5-point Likert scale ranging from highly unlikely to highly likely (2) a set of user motivations to use the app to estimate the constructs in relation to the ERG model (3) perceived barriers to use the app in terms of usage difficulties and information privacy concern (4) environmental attitude and (5) a set of background variables such as age, gender, income, travel habit, family status etc.

With respect to the ERG model, respondents were asked the question, “How can registration for the “GREEN account” satisfy your travel needs for the daily commute?”. The statements of the three dimensions of the ERG model were measured using the 5-point Likert scale ranging from strongly disagree to strongly agree.

Existence needs incorporated items related to increasing travel efficiency such as travel time and monetary savings when using travel information. Travel time and cost savings were defined as functional needs based on previous studies presenting trip efficiency as the most desired feature for the users of travel information (Chorus et al., 2007; Grotenhuis et al., 2007). Furthermore, in a literature based study, Vogelsang et al. (2015) proposed a framework for integrating the needs of travelers and app users and identified travel time and cost savings amongst the main factors that guide the use of travel information.

Relatedness needs explored items regarding travel information sharing and its value for users to form or maintain interpersonal relationships and satisfy a sense of belonging. In the field of social psychology, sociology and marketing, theories and research argue that products have social value, which may guide product purchase and use, e.g. theory on the extended self (Belk, 1988), theory on the meaning of material possessions (Dittmar, 1993), theory on brand concept management (Park et al., 1986) and self-congruity theory (Sirgy, 1986). Social value reflects 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 for developing social self-concept.

Growth needs investigated items related to developing environmental self-identity (e.g. adopting a more environmentally-friendly travel behavior and contributing to sustainable development of the city)

as well as self-concept associated with self-confidence and self-efficacy to embark on travel behavior changes.

The perceived barriers for using the app were expressed as perceived usage difficulties (e.g. ease of use, mental relaxation and relative advantages related to the offered incentives) and perceived risk when it comes to information provision online. We employed the conceptualization of information privacy concern inventory developed by Hong and Thong (2013) in an online context. In our study, the model included the four dimensions of "Information collection", "Secondary usage", "Improper access" and "Trusting beliefs". Information collection refers to "the degree to which a person is concerned about the amount of individual specific data possessed". Secondary usage is "the degree to which a person is concerned that personal information is collected for one purpose but is used for another, secondary purpose without authorization from the individual". Improper access refers to "the degree to which a person is concerned that personal information is readily available to people not properly authorized to view or work with the data". Trusting beliefs refer to "the degree to which people believe a service provider is dependable in protecting personal information". The conceptual framework of information privacy concern is presented in Figure 2-2. The information privacy concern is the second order factor measured by those four first-order factors. The statements of perceived barriers were measured using the 5-point Likert scale ranging from strongly disagree to strongly agree.

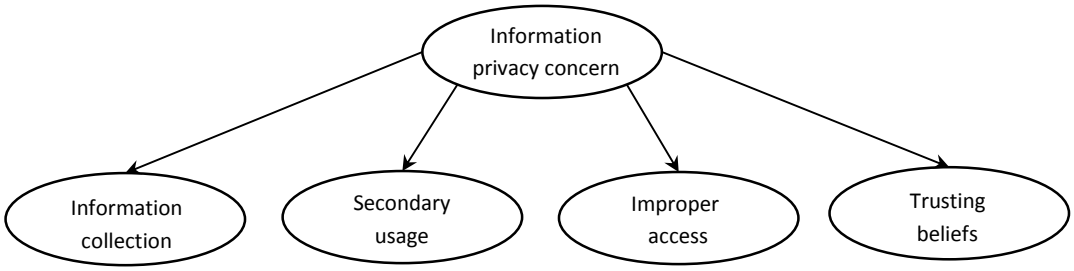

Figure 2-2 Conceptual model on information privacy concern

We assess environmental attitudes with the Environmental Attitude Inventory (EAI) developed by Milfont and Duckitt (2010) after shortening and adapting it to the context of online travel information provision. The environmental attitude incorporated the four dimensions of personal conservation behavior (i.e. taking care of resources and environmental protection in personal daily behavior such as energy saving and recycling), trust in travel information technology (i.e. belief in the ability of the information technology to alleviate traffic issues and promote environmental friendly travel behavior), human impact on environment (i.e. belief in negative environmental consequences of economic progress and a need for adopting more serious action) and environmental movement activism (i.e. personal interest and desire to support or participate in organized actions related to environmental issues).

Individual characteristic comprised socio-economic variables and travel habits. The travel habits comprised frequency of traveling by car, public transport and bicycle as well as the frequency of commuting alone, with others (i.e. necessarily adults) and with children. The frequency was measured

on a 5-point 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 to give information about the membership cards they held, since we wanted to test whether there is a relationship between the number of memberships held by each individual and the degree of online privacy concern. The question included multiple choices of supermarket/shopping club cards, fitness club, car/bike sharing, housing association and labor union.

The survey was administered in Danish from mid-May to mid-June 2017 to a sample of commuters who were older than 18 and resided or worked 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, and they were therefore contacted directly. The questionnaire was distributed amongst the companies registered in the list of the Danish Bureau of Statistics. Companies with more than ten employees located in the region were included. For the sake of recruitment, more than 5000 email invitations were sent. Copenhagen municipality also posted the questionnaire on their portal for distributing to its employees which allowed obtaining a larger sample size.

The survey yielded 828 fully completed responses. It is considered as an adequate sample size based on a rule of thumb of requiring ten responses for each of the 39 indicators designed for our study (Nunnally et al., 1967). Table 2-A shows the sample characteristics compared to the data from the Danish National Travel Survey (TU) presented in brackets. The TU data used included only the greater Copenhagen area from 2015 to 2017 and adult people who commuted either by passenger car or public transport or active modes.

Variable	Categories				
Gender	Male	Female			
	50% (49%)	50% (51%)			
Age	Age 18-29	Age 30-39	Age 40-49	Age 50-59	Age>60
	33% (23%)	21% (21%)	19% (20%)	18% (16%)	10% (21%)
Employment	Student	Part time	Full time	Other	
	22% (12%)	4% (11%)	69% (54%)	5% (23%)	
Family status	Single no children	Couple no children	Single with children	Couple with children	
	19% (30%)	45% (31%)	4% (5%)	31% (34%)	
Commute distance	0-5 km	6-10 km	11-20 km	21-30 km	> 30 km
	19% (39%)	24% (17%)	28% (11%)	12% (4%)	17% (29%)
Annual income before tax (DKK)	Under 200,000	200,000 – 400,000	400,000 – 500,000	500,000 – 750,000	Over 750,000
	22% (28%)	29% (37%)	22% (16%)	20% (14%)	8% (6%)
Income groups in this study	Low	Medium	High medium	High	High
Number of membership cards *	No membership	1	2	3	More than 4
	12%	29%	35%	19%	4%
** Since this data, in this format, is not available in TU, they were not compared.*					

Table 2-A Sample characteristics, Total sample size = 828

The sample characteristics are in line with the survey aim and scope to target adult commuters in the Greater Copenhagen Area. The sample is gender-balanced which agrees with the TU data, and mostly

includes adults who are students or full-time employees. Our sample is considerably different from the TU data in many categories, which was anticipated due to the choice of recruitment. For example, almost one fourth of the participants were 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 through companies not directly.

2.7. Results

2.7.1. Factor analysis

All the constructs of the behavioral framework including ERG needs, perceived usage difficulties, information privacy concern, and environmental attitude were obtained by exploratory factor analysis (EFA). EFA was employed to expose the underlying structure of the variables and investigate the theoretical constructs.

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 the Bartlett's test for sphericity rejected the null hypothesis of an identity correlation matrix. Principal axis factoring (PAF) with orthogonal "Varimax" rotation generated the three factors of the ERG needs, the five factors of the perceived barriers, and the four factors of environmental attitude. Both the scree plot and parallel analysis implemented in R package "psych" (Revelle, 2016) suggest the same number of factors (refer to Appendix A for details). Regarding the generated factors, Tables 2-B through 2-D below show the loadings of the dominant items and their descriptions. The cut off of 0.5 was set to retain a set of items representing the factors. The Cronbach's alpha of each factor is also presented in brackets. Most of the Cronbach's alpha values are above 0.7 reflecting good internal consistency (Miller, 1995), except for F4 and F11 that are just acceptable since they are above the "criterion-in-use" of 0.6 (Peterson, 1994).

As shown in Table 2-B, factors F1, F2 and F3 are related to the satisfaction of personal needs. Factor F1, "Trip-efficiency improvement", includes two items of satisfying basic travel needs in terms of saving travel time and cost by using the app. Factor F2, "Social self-concept development", is about the social attributes of the app to satisfy relatedness needs. It incorporates all statements about social interaction, sharing information, helping others and gaining social approval. Factor F3, "Eco-travel promotion", is associated with the value of using the app to satisfy higher order needs of self-efficacy (e.g. changing travel behavior for the sake of one's own health, the city or the environment) and develop an environmental self-identity. In Table 2-C, factor F4, "Perceived usage difficulties", includes the personal perceptions of the app being generally unappealing, stressful and unattractive in terms of the offered incentives. Factors F4, F5, F6 and F7 are about the four dimensions of information privacy concern, of which the first three include the perceived risks and the last one the perceived trust of online information provision. As shown in Table 2-D, factors F9, F10, F11 and F12 include the four dimensions of environmental attitude as explained previously.

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 our sample size is not small, the model is not susceptible to estimation problems (Kline, 2011).

It is worth mentioning that the factor structure extracted by the EFA was then used to perform the SEM model. The aim of the EFA was to identify underlying constructs for a set of measured variables in the absence of a priori hypotheses, whereas the aim of the CFA was to test how well the data fit a hypothesized, a priori, measurement model. When it comes to our data set, the factor structure is initially revealed by EFA and then used as part of the model structure with CFA, which improves the structural validity of the proposed model.

Factor name (Cronbach α)	Acronym	Item	Factor loadings
F1 (0.82)	TE1	It would save me travel time	0.77
Trip efficiency improvement	TE2	It would make my trip cheaper	0.77
F2 (0.85)	SS1	Sharing my CO2 savings and burnt calories on my social media could be fun	0.83
Social self-concept development	SS2	I could enlarge my social network with sharing my trip information	0.83
	SS3	I would feel part of the community	0.54
	SS4	I could help others by sharing my CO2 savings on social media	0.74
F3 (0.88)	EP1	It would help me make healthier travel choices	0.76
Eco-travel promotion	EP2	It would help me make greener travel choices	0.84
	EP3	I could contribute to the city vision for CO2 level reduction	0.64
	EP4	"GREEN account" would make my trip more environmentally friendly	0.75
Cronbach’s alpha=0.88, KMO = 0.85, Determinant of the Spearman correlations matrix= 0.0043			

Table 2-B Rotated factor matrix for the ERG needs

Factor name (Cronbach α)	Acronym	Item	Factor loadings
F4 (0.64)	UD1	I would not like to run the app while travelling	0.51
Perceived usage difficulties	UD2	Trying to earn eco-points could be stressful	0.50
	UD3	The offered incentives do NOT answer my needs	0.54
	UD4	"GREEN account" is too time consuming compared to the offered benefits	0.61
F5 (0.78)	IC1	It bothers me when they ask me for personal information	0.72
Information collection	IC2	I think twice about providing my personal information	0.55
	IC3	I am concerned they collect too much information about me	0.75
F6 (0.88)	SU1	My personal information could be used for other purposes	0.49
Secondary usage	SU2	Providers could sell my personal information to third parties	0.82
	SU3	Providers could share my personal information without my authorization	0.52
F7 (0.88)	IA1	The databases are not protected from unauthorized access	0.82
Improper access	IA2	Providers generally do not devote enough effort for preventing unauthorized access	0.80
	IA3	Websites can be hacked and leak personal information to the public	0.75
F8 (0.88)	TB1	They will keep my best interests in mind when dealing with my personal info	0.78
Trusting beliefs	TB2	They fulfill their promises related to my personal information	0.86
	TB3	They are predictable/reliable for the usage of my personal info	0.83
Cronbach’s alpha= 0.75,KMO = 0.88, Determinant of the Spearman correlations matrix= 0.0003			

Table 2-C Rotated factor matrix for the perceived barriers constructs

Factor name (Cronbach α)	Acronym	Item	Factor loadings
F9 (0.78)	HI1	If things continue on their present course, we will soon experience a major env. crisis	0.63
Human impact on	HI2	People have been giving little attention to how economic progress damaging the env.	0.75
environment	HI3	The negative env.* effects of economic growth should be considered by politicians	0.77
F10 (0.76)	TT1	Better travel information helps to reduce traffic congestion	0.71
Trust in travel Info	TT2	The internet technology reduces people's daily travel	0.73
technology	TT3	Better travel information is useful to travel in a greener way	0.69
F11 (0.65)	PC1	At home, I control the heating system so the temp is not too high	0.49
Personal	PC2	I always turn off the light when I leave the room	0.57
conservation	PC3	I save water as much as I can	0.77
behavior	PC4	I recycle waste as much as I can	0.50
F12 (0.75)	EM1	I believe that social and environmental campaigns make a difference	0.59
Environmental	EM2	I am prepared to help out in environmental campaigns	0.71
movement activism	EM3	I sign petitions or donate money to support an environmental issue	0.66

Cronbach's alpha=0.78, KMO = 0.80, Determinant of the Spearman correlations matrix=0.0029
** env. stands for environment/environmental*

Table 2-D Rotated factor matrix for the environmental attitude

2.7.2. Model estimation results

The Shapiro-Wilks test for univariate normality (Shapiro and Wilk, 1965), as well as the Mardia's test for multivariate normality (Mardia, 1970), shown in Appendix 2.B, rejected the null hypothesis that the sample comes from a multivariate normal distribution. Thus, Maximum Likelihood with Huber-White covariance adjustment was employed to estimate the model parameters (Yuan and Bentler, 2000).

The model comprising both structural and measurement equations fits the data reasonably well. The scaling correction factor, the standard chi-square divided by the scaled chi-square, is 1.059 indicating that the non-normality is not problematic, i.e. the chi-square inflation is less than 10% (Newsom, 2005). The chi-square to degrees of freedom ratio is 2.17 (χ^2 = 3059.728, df = 1407), which is indicative of an "acceptable" data-model fit (Schermelleh-Engel et al., 2003). The tested model revealed a goodness-of-fit measure in terms of RMSEA equal to 0.038. The SRMR is 0.071 within the acceptable range of 0.05-0.08 (Hu and Bentler, 1999). The CFI is 0.890, which is also acceptable as suggested by Loehlin (1998). Tables 2-E through 2-H show the standardized parameters estimates, critical ratios (C.R.), defined as the ratio of parameter estimate and standard error, as well as p-values.

Table 2-E presents the estimates of the measurement equations of the CFA that agrees with the EFA displayed in Tables 2-B, 2-C and 2-D.

Factor name	Item	*est.*	*C.R.*	*p-value*
Trip efficiency	It would save me travel time	1.000	-	-
Improvement (F1)	It would make my trip cheaper	1.086	17.847	<0.001
Social self-concept	Sharing my CO2 savings and burnt calories on my social media could be fun	1.000	-	-
development (F2)	I could enlarge my social network with sharing my trip information	0.858	28.786	<0.001
	I would feel part of the community	0.684	10.528	<0.001
	I could help others by sharing my CO2 savings on social media	0.872	15.033	<0.001
Eco-travel	It would help me make healthier travel choices	1.000	-	
promotion (F3)	It would help me make greener travel choices	1.071	45.048	<0.001
	I could contribute to the city vision for CO2 level reduction	0.677	19.054	<0.001
	"GREEN account" would make my trip more environmentally friendly	0.925	28.495	<0.001
Perceived usage	I would not like to run the app while travelling	1.000	-	-
difficulties (F4)	Trying to earn eco-points could be stressful	1.008	8.110	<0.001
	The offered incentives do NOT answer my needs	1.214	8.476	<0.001
	"GREEN account" is too time consuming compared to the offered benefits	1.022	9.281	<0.001
Information	It bothers me when they ask me for personal information	1.000	-	-
collection (F5)	I think twice about providing my personal information	0.542	13.451	<0.001
	I am concerned they collect too much information about me	1.038	25.466	<0.001
Secondary usage	My personal information could be used for other purposes	1.000	-	-
(F6)	Providers could sell my personal information to third parties	1.172	29.454	<0.001
	Providers could share my personal information without my authorization	1.104	22.162	<0.001
Improper access	The databases are not protected from unauthorized access	1.000	-	-
(F7)	Providers generally do not devote enough effort for preventing unauthorized access	0.918	31.598	<0.001
	Websites can be hacked and leak personal information to the public	0.946	31.696	<0.001
Trusting beliefs	They will keep my best interests in mind when dealing with my personal info	1.000	-	-
(F8)	They fulfill their promises related to my personal info	1.014	28.590	<0.001
	They are predictable/reliable for the usage of my personal info	1.013	26.574	<0.001
Human impact on	If things continue on their present course, we will soon experience a major env crisis	1.000	-	-
environment (F9)	People have been giving little attention to how economic progress damaging the env.	1.246	13.070	<0.001
	The negative env. effects of economic growth should be considered by politicians	1.067	12.916	<0.001
Trust in travel Info	Better travel information helps to reduce traffic congestion	1.000	-	-
Technology (F10)	The internet technology reduces people's daily travel	1.181	15.165	<0.001
	Better travel information is useful to travel in a greener way	1.113	12.426	<0.001
Personal	At home, I control the heating system so the temp is not too high	1.000	-	-
conservation	I always turn off the light when I leave the room	1.006	8.891	<0.001
behavior (F11)	I save water as much as I can	1.426	8.943	<0.001
	I recycle waste as much as I can	0.952	7.175	<0.001
Environmental	I believe that social and environmental campaigns make a difference	1.000	-	-
movement activism	I am prepared to help out in environmental campaigns	1.273	17.434	<0.001
(F12)	I sign petitions or donate money to support an environmental issue	1.308	15.842	<0.001

Table 2-E Estimates of the measurement equations of the latent constructs

Table 2-F presents the relationships between the first-order factors and information privacy concern according to the conceptual model shown in Figure 2-2.

Factor name		*est.*	*C.R.*	*p-value*
Information privacy concern (F13)	Information collection (F5)	1.000	-	-
	Secondary usage (F6)	1.063	15.872	<0.001
	Improper access (F7)	1.040	13.186	<0.001
	Trusting beliefs (F8)	-0.489	-9.003	<0.001

Table 2-F Factor loadings of the information privacy concern construct

Table 2-G shows the structural equations linking the latent variables of ERG, information privacy concern and perceived usage difficulties to individual characteristics. Table 2-H shows the structural equations relating the ERG needs with environmental attitude, as well as the intention to use the "GREEN account" with the ERG needs and perceived barriers. In Tables 2-G and 2-H, a threshold of p-value < 0.1 was used to decide which factors would be left in the model.

Factor name		*est.*	*C.R.*	*p-value*
Trip efficiency improvement (F1)	Male	-0.170	-2.734	0.006
	Age 30-39	-0.341	-4.096	<0.001
	Age 40-49	-0.437	-4.758	<0.001
	Age 50-59	-0.462	-4.838	<0.001
	Age 60+	-0.461	-4.186	<0.001
	Transit use frequency: Daily	0.143	1.759	0.079
	Transit use frequency: 2-3 days a week	0.185	1.999	0.046
	Car use frequency: Daily	0.201	2.708	0.007
	Car use frequency: 2-3 days a week	0.264	2.819	0.005
Social self-concept development (F2)	Male	0.120	1.699	0.089
	Traveling with adult partner: 2-3 days a week	0.277	2.505	0.012
Eco-travel promotion (F3)	Male	-0.101	-1.982	0.048
	Income: Low	0.245	3.400	0.001
	Income: Medium	0.114	1.812	0.070
	Family with children	0.191	3.462	0.001
	Travel distance	-0.044	-2.388	0.017
	Bike use frequency: Daily	-0.227	-3.706	<0.001
Perceived usage difficulties (F4)	Male	0.142	3.256	0.001
	Age 60+	0.197	2.585	0.010
	Income: Low	-0.167	-2.852	0.004
	Income: Medium	-0.122	-2.238	0.025
	Transit use frequency: Daily	-0.156	-2.994	0.003
	Transit use frequency: 2-3 days a week	-0.135	-2.062	0.039
	Bike use frequency: Daily	-0.166	-3.307	0.001
	Bike use frequency: 2-3 days a week	-0.159	-2.706	0.007
Information privacy concern (F13)	Age 40-49	0.133	1.807	0.071
	Age 50-59	0.272	4.018	<0.001
	Age 60+	0.322	3.534	<0.001
	Number of membership cards	-0.041	-1.708	0.088

Table 2-G Linkage between individual characteristics and the ERG needs and perceived barriers

Dependent (mediator) variables	Explanatory variables	*Direct effect*			*Total effect*		
		est.	*C.R.*	*p-value*	*est.*	*C.R.*	*p-value*
Trip efficiency improvement (F1)	Trust in travel Info technology (F10)	0.436	5.658	<0.001	0.436	5.658	<0.001
	Personal conservation behavior (F11)	0.202	2.293	0.022	0.202	2.293	0.022
Social self-concepts development (F2)	Trip efficiency improvement (F1)	0.448	9.068	<0.001	0.448	9.068	<0.001
	Trust in travel Info technology (F10)	-	-	-	0.195	4.595	<0.001
	Personal conservation behavior (F11)	-	-	-	0.091	2.226	0.026
	Environmental movement activism (F12)	0.574	7.747	<0.001	0.574	7.747	0.000
Eco-travel promotion (F3)	Trip efficiency improvement (F1)	0.396	7.243	<0.001	0.490	9.405	<0.001
	Social self-concepts development (F2)	0.208	6.515	<0.001	0.208	6.515	<0.001
	Human impact on environment (F9)	0.138	2.488	0.013	0.138	2.488	0.013
	Trust in travel Info technology (F10)	0.452	6.555	<0.001	0.666	8.478	0.000
	Personal conservation behavior (F11)	-	-	-	0.099	2.242	0.025
	Environmental movement activism (F12)	-	-	-	0.119	4.791	0.000
Intention to use the "GREEN account"	Trip efficiency improvement (F1)	-	-	-	0.272	7.856	<0.001
	Social self-concepts development (F2)	0.098	2.227	0.026	0.195	4.812	<0.001
	Eco-travel promotion (F3)	0.466	6.677	<0.001	0.466	6.677	<0.001
	Perceived usage difficulties (F4)	-0.826	-6.477	<0.001	-0.826	-6.477	<0.001
	Information privacy concern (F13)	-0.197	-3.106	0.002	-0.197	-3.106	0.002
	Human impact on environment (F9)	-	-	-	0.064	2.194	0.028
	Trust in travel Info technology (F10)	-	-	-	0.329	5.795	<0.001
	Personal conservation behavior (F11)	-	-	-	0.055	2.192	0.028
	Environmental movement activism (F12)	-	-	-	0.112	3.824	<0.001

Table 2-H Linkage between the ERG needs, perceived barriers, environmental attitude and the use intention

Figure 2-3 displays the path diagram of the model structure. The full path diagram is reported in Appendix 2.C.

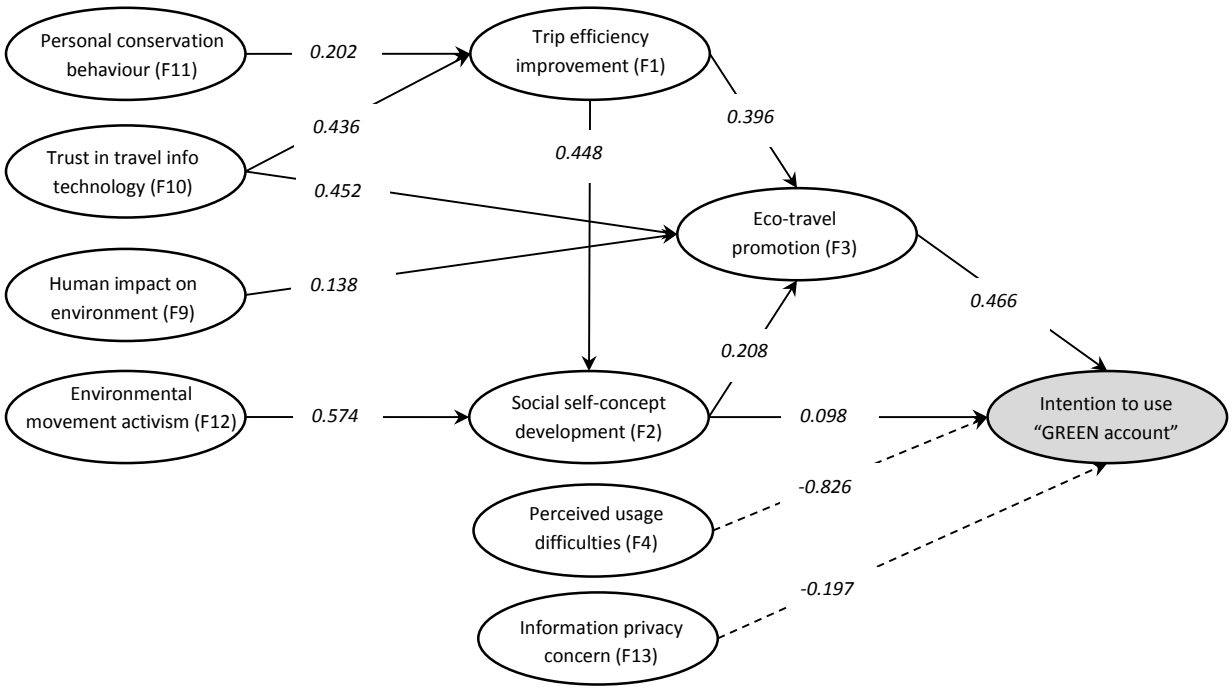

Figure 2-3 Model structure

The relation between the ERG needs, perceived barriers and individual characteristics

As shown in Table 2-G, trip efficiency improvement is higher for individuals who travel more frequently with car and public transport. The results also show gender and age effects as the moderating variables between the functional motivation and individuals' intention to use the app. These two variables have been widely explored by previous technology acceptance studies (refer to the literature review by Williams et al. (2015)).

Developing social self-concepts is associated positively with individuals who travel 2-3 days a week with another adult i.e. friends, colleagues, partners and spouse. The results also show that the social motivation is stronger for men. Since the social attributes of the app mostly include information-sharing, the reason could be explained by different motives for using social media as a means of self-presentation. Men are more likely to use social networking for making new friends while women reported using them more for relationship maintenance (Haferkamp et al., 2012; Muscanell and Guadagno, 2012). Hence, men appear to perceive the sharing of collected eco-points, CO2 emission savings etc., more importantly as this feature would enable them to enlarge their social network and communicate with new people.

Eco-travel promotion relates negatively to men and increasing travel distance, and positively to low and middle income rather than high income, indicating differences in eco-travel self-efficacy. Previous studies asserted that women, residents with shorter travel distance and with high income are more likely to adopt environment-friendly travel (e.g., Clark et al., 2016; López-Mosquera et al., 2015; Prillwitz and Barr, 2011; Yang et al., 2013). When it comes to gender and travel distance, the results are in line with recent studies, while it is the opposite for income. This can be explained by the attractiveness of the gamification elements (i.e. offered incentives and rewards) for the lower income groups. For example, the construct of usage difficulties which includes consumer's perceptions of the gamification is less important for the lower income groups which can support this argument. Furthermore, car ownership may be considered as another reason for the opposite finding. Since the respondents were not asked about their car-ownership in the survey, its effect can be deduced from the results of two previous studies. Halldórsdóttir et al. (2011) investigated the mode choice behavior of citizens in the Greater Copenhagen Area and found that the bicycle mode choice is negatively linked to car ownership. Another study in the same region by Knudsen (2015) supported a positive relationship between income and car ownership. Since car ownership increases with higher incomes, it may have a negative effect on the motivation of this group for eco-traveling. Eco-travel promotion is stronger for families with children, possibly due to the need to serve as role models. Environmental motivation is perceived as weaker for daily cyclists. This result can be explained, as individuals who bike daily already use a sustainable and healthier travel choice and, accordingly, contribute to CO2 emissions reduction. They may not feel capable of changing travel behavior toward a healthier and greener pattern due to the level of difficulty of the behavior change (i.e. self-efficacy expectancy; Bandura, 1991).

When it comes to the barriers, the usage difficulties are more significant for men and the oldest group, while they are perceived less significant for frequent public transport and bike users as well as lower

income groups. When the number of respondents' membership cards increases, they become less concerned about information privacy issues. The study results also show that privacy concern is more important for older ages. In the online context, recent literature reported that younger and older adults are different in the level of privacy concern, awareness of privacy issues and data protection (Blank et al., 2014; Lee and Coughlin, 2015; Park, 2015; Zeissig et al., 2017). Older adults show higher levels of concern, a more active protection behavior and lower self-efficacy in privacy control (Zeissig et al., 2017) which may trigger to avoid or stop the use of online tools (Lee and Coughlin, 2015).

The relation between the ERG needs, environmental attitude, perceived barriers and intention to use

As displayed in Table 2-H and Figure 2-3, the model structure supported hypothesis H1 that the perceived functional and psychological user needs relate positively to the adoption intention. It indicates that acceptance and use of the VTBC-based travel app is associated not only with functional motivation but also with psychological motivations. The specific results show that the adoption intention is linked directly to the higher order needs of eco-travel promotion and social self-concept development, while trip efficiency improvement did not show a direct causal effect. The two factors play the role of mediators between the perceived functional need and the adoption intention. It means that a greater perception of the benefits of the app to increase trip efficiency leads to a greater perception of its benefits to develop social self-identity as well as eco-travel self-efficacy which, in turn, translates into adoption. Such relationship between these three groups of core needs agree with Alderfer's ERG model of human needs in which the existence and relatedness needs are satisfied and the two are significant in developing growth needs.

The model structure confirmed hypotheses H2 and H3 that the perceived barriers relate negatively to the adoption intention. Information privacy concern is negatively related to the use and acceptance of the app, suggesting that individuals with a higher level of privacy concerns are less likely to register for the "GREEN account". Likewise, individuals who perceive the usage difficulties of the app as important are less likely to use the account. In the survey, the items concerning the usage difficulties were primarily about the individual interest in running the app as well as the offered incentives. The coefficient for the effect of this construct on the use intention is the highest negative one, indicating its key importance as a reason against VTBC-based travel app adoption.

The model also supported hypothesis H4, in which perceived user needs mediate the effect of environmental attitude on adoption intention. Strong positive attitude toward travel information technology had a positive influence on both perceived functional and growth needs. Having favorable attitudes toward travel information technologies (i.e. as an effective tool to reduce traffic congestion, avoid unnecessary daily travel and encourage eco-friendly travel) is likely to help them gain a positive evaluation of the app for either improving trip efficiency or promoting green travel.

Individuals who are aware of, or concerned about, the consequences of environmental problems perceive the value of the app to promote environmental friendly travel behavior as more important. Previous studies assert that environmental awareness tends to form favorable attitudes toward

environmentally responsible behavior (Han and Yoon, 2015; Kim and Han, 2010; Lin and Syrgabayeva, 2016).

A big interest in, and desire, to engage in organized action relates positively to the perceived relatedness needs. Volunteerism research and theory suggest that personal basic goals and needs vary across a population. This is significant in understanding the motivations that drive people to take up causes and social action. To the extent that people perceive good correspondence between their volunteering and personal motivations and goals, they are likely to engage in those activities (Mannino et al., 2010; Omoto and Snyder, 2016; Stukas et al., 2009). Asah and Blahna (2012) argued that environmental protection is only an important motivator when coupled with community, social and personal goals. In their study, the protection of the environment was less of a motivator than the human goals such as social interaction. Other studies also pointed out the significant role of social interaction motivations for participation in organized environmental actions (Bramston et al., 2011; Measham and Barnett, 2008). In our study, a big personal interest in, and desire to, support and participate in environmental actions appears to form positive attitude toward social attributes of the app and its value for social interaction.

When it comes to the relationships between the environmental attitude and the ERG needs, the findings are in line with the expectations except for the construct of “Personal conservation behavior”. Prior studies have shown that performing pro-environmental behavior strengthens environmental self-identity i.e. “more strongly see himself or herself as the type of person who will act environmentally-friendly and consequently be more likely to act pro-environmental” (van der Werff et al., 2014, 2013a, 2013b). Our result suggests that individuals that exhibited a more conservation-oriented behavior appear to perceive the functional value of the app as more important than the value of promoting eco-travel behavior. Although there is no straightforward explanation, the intuition behind this result can be explained by the negative spillover effect whereby one pro-environmental behavior deters performing additional pro-environmental behaviors (Thøgersen and Crompton, 2009; Truelove et al., 2014).

In summary, these results suggest that environmental attitude, user’ needs, perceived barriers and intention to use a VTBC-based travel app are associated. Based on these data, it can be inferred that an individual's perceived needs toward the use of the travel app are highly relevant to the individual's general attitudes of performing conservation behavior, environmental awareness, trust in travel information technology and support of organized environmental actions that influence its adoption. Furthermore, behavioral intention to use the travel app is positively directly affected by psychological needs and indirectly by functional needs. Likewise, the behavioral intention relates negatively to perceived barriers of usage difficulties and information privacy concern.

2.8. 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. Future research should address this issue.

Moreover, the data were collected focusing on daily commuters. It would be useful to replicate this study using other travel purposes in order to better attain the robustness of the results across travel purposes. The relations found in this study for Denmark could also be validated in cross-cultural settings due to possible cultural differences in perceptions.

Secondly, the exclusive focus on individuals and their responsibility to promote sustainable mobility neglects the social dynamics outside the system condition and the need for change at other scales beyond the individual user (Brynjarsdottir et al., 2012; Gabrielli et al., 2014). The approach is reasonable considering the role of individualism in Danish society. We encourage future researchers to explore the role of communities and collective efficacy and responsibility in addition to individual responsibility.

Lastly, the proposed app is currently under development, and during the survey administration, the new travel app has not yet been deployed. Hence, the study focuses on the pre-adoption stage. 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 modifications.

2.9. Conclusion

The prevalence of smartphone use, the rise in mobile device sensors and the popularity of social networks for sharing information have pushed decision makers into thinking that collaborative travel apps could be a key to promote behavior change toward eco-friendly travel modes. However, the literature review revealed a lack of understanding 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 ability of the travel app to satisfy functional and psychological human needs of relatedness and growth. Comparable to Noppers et al (2014), who investigated three groups of motivations for adopting sustainable innovations, we show that also for VTBC-based travel apps, the use intention is explained by functional, social and environmental motives. More specifically, a good evaluation of the ability of the app to improve trip efficiency leads to a good evolution of its social and environmental attributes and, in turn, translates into its adoption.

Thus, the results support the hypothesis that the adoption of VTBC-based travel apps is not exclusively guided by their functional utility, but also by their ability to satisfy emotional needs by triggering feelings of sense of belonging, social identification and developing environmental self-identity as well as eco-travel self-efficacy. It highlights self-monitoring, information sharing and gamification elements (i.e. incentives and rewards) as appealing persuasive strategies promoting and driving engagement, which should therefore be stressed throughout the process of system development, business design and marketing.

Furthermore, the results show that the barriers embedded in the attributes of the travel app negatively influence its adoption. In other words, the study shows the need for consideration of reasons against, together with reasons for, in order to better explain the adoption of the VTBC-based travel app. Two

dimensions that seem to have influence in the appraisal of acceptance of the app, relate with low usage risk and high usability.

The findings also imply that environmental awareness, favorable attitude toward travel information technologies, performing conservation behavior, and a personal desire to participate in organized environmental activities, affect individuals' perceptions of the benefits of the travel app and play a significant role in explaining their adoption decision formation. The study has also provided authorities and app designers with an understanding of different user groups, which aspects of VTBC-based travel apps they value and accordingly their motivations and barriers for using them.

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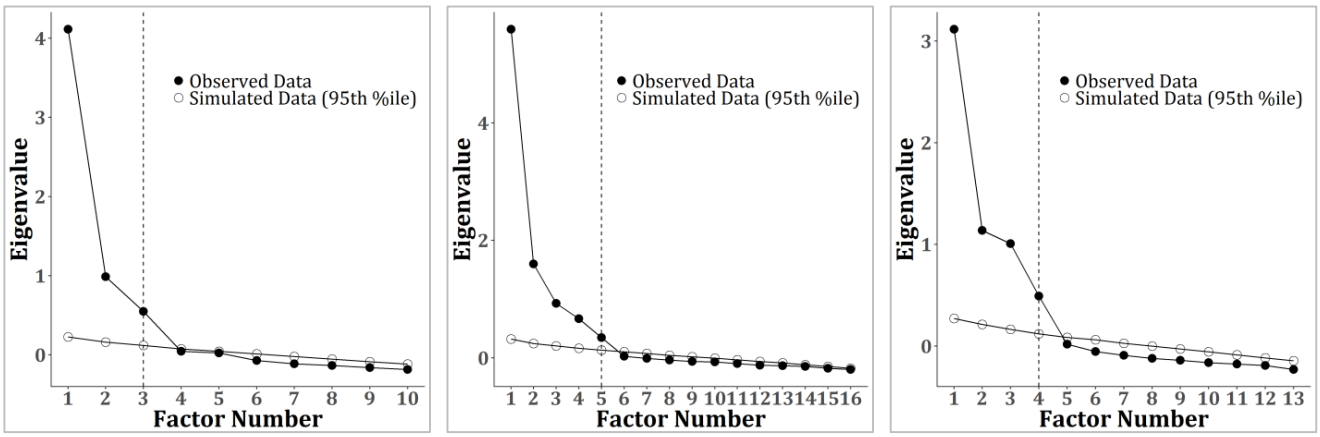
Appendix 2.A

Figure 2-4 shows the scree plot/parallel analysis of the indicators of the model, implemented by R package "psych". The vertical line indicates parallel analysis suggested maximum number of factors to retain.



(a) ERG needs (b) Perceived barriers (c) Environmental attitude

Figure 2-4 Scree plot/parallel analysis for the indicators of the model

Appendix 2.B

Description	Mean	St.Dev	Skew	Kurtosis	Shapiro-Wilk statistic*
It would save me travel time	2.977	1.061	-0.082	2.360	0.913
It would make my trip cheaper	3.158	1.053	-0.269	2.559	0.908
Sharing my CO2 savings and burnt calories on social media could be fun	2.344	1.225	0.495	2.103	0.867
I could enlarge my social network with sharing my trip information	2.209	1.065	0.549	2.529	0.871
I would feel part of the community	2.866	1.145	-0.162	2.171	0.903
I could help others by sharing my CO2 savings on social media	2.489	1.141	0.298	2.252	0.897
It would help me make healthier travel choices	3.489	1.066	-0.638	2.823	0.877
It would help me make greener travel choices	3.646	1.082	-0.784	3.058	0.862
I could contribute to the city vision for CO2 level reduction	3.835	0.855	-1.072	4.772	0.806
"GREEN account" would make my trip more environmentally friendly	3.667	0.997	-0.849	3.535	0.853
I would not like to run the app while travelling	2.903	0.916	0.267	2.860	0.891
Trying to earn eco-points could be stressful	2.566	0.989	0.359	2.676	0.897
The offered incentives do NOT answer my needs	2.452	1.067	0.521	2.636	0.889
"GREEN account" is too time consuming compared to the benefits	2.845	0.811	0.098	3.781	0.845
It bothers me when they ask me for personal information	3.466	1.065	-0.386	2.416	0.896
I think twice about providing my personal information	4.161	0.791	-0.967	4.131	0.795
I am concerned they collect too much information about me	3.786	1.001	-0.561	2.659	0.873
My personal information could be used for other purposes	3.903	0.910	-0.937	3.750	0.821
Providers could sell my personal information to third parties	4.014	1.014	-1.019	3.508	0.818
Providers could share my personal information without my authorization	3.994	1.008	-0.951	3.322	0.825
The databases are not protected from unauthorized access	3.986	0.988	-0.836	3.091	0.838
Providers generally do not devote enough effort for preventing unauthorized access	3.808	0.950	-0.354	2.404	0.873
Websites can be hacked and leak personal information to the public	3.824	1.015	-0.662	2.780	0.864
They will keep my best interests in mind when dealing with my personal information	3.126	0.911	-0.442	2.831	0.877
They fulfill their promises related to my personal information	3.258	0.852	-0.508	3.186	0.863
They are predictable/reliable for the usage of my personal info	3.143	0.861	-0.448	3.184	0.867
If things continue on their present course, we will soon experience a major env. crisis	3.990	0.929	-0.913	3.636	0.833
People have been giving little attention to how economic progress damaging the env.	4.002	0.936	-0.864	3.332	0.833
The negative env. effects of economic growth should be considered by politicians	4.262	0.827	-1.275	5.063	0.770
Better travel information helps to reduce traffic congestion	3.960	0.762	-0.903	4.764	0.800
The internet technology reduces people's daily travel	3.606	0.925	-0.51	3.103	0.879
Better travel information is useful to travel in a greener way	3.924	0.782	-0.867	4.514	0.811
At home, I control the heating system so the temp is not too high	3.902	0.948	-0.997	3.925	0.827
I always turn off the light when I leave the room	4.256	0.817	-1.061	4.011	0.785
I save water as much as I can	3.941	0.885	-0.701	3.245	0.849
I recycle waste as much as I can	4.157	0.930	-1.101	3.877	0.798
I believe that social and environmental campaigns make a difference	3.594	0.842	-0.596	3.515	0.855
I am prepared to help out in environmental campaigns	3.216	0.960	-0.205	2.780	0.901
I sign petitions or donate money to support an environmental issue	3.017	1.146	-0.154	2.212	0.913
Mardia test	Statistic		P-value		
Mardia Skewness	20796.51		<0.001		
Mardia Kurtosis	73.97		<0.001		

** The Shapiro–Wilk test statistic is significantly different than unity at the 0.01 significance level for all the items.*

Table 2-I Univariate and multivariate normality tests for the attitudinal items.

Appendix 2.C

Figure 2-5 shows the full path diagram of the model. The acronym of indicators is according to the items described in Tables 2-B, 2-C and 2-D.

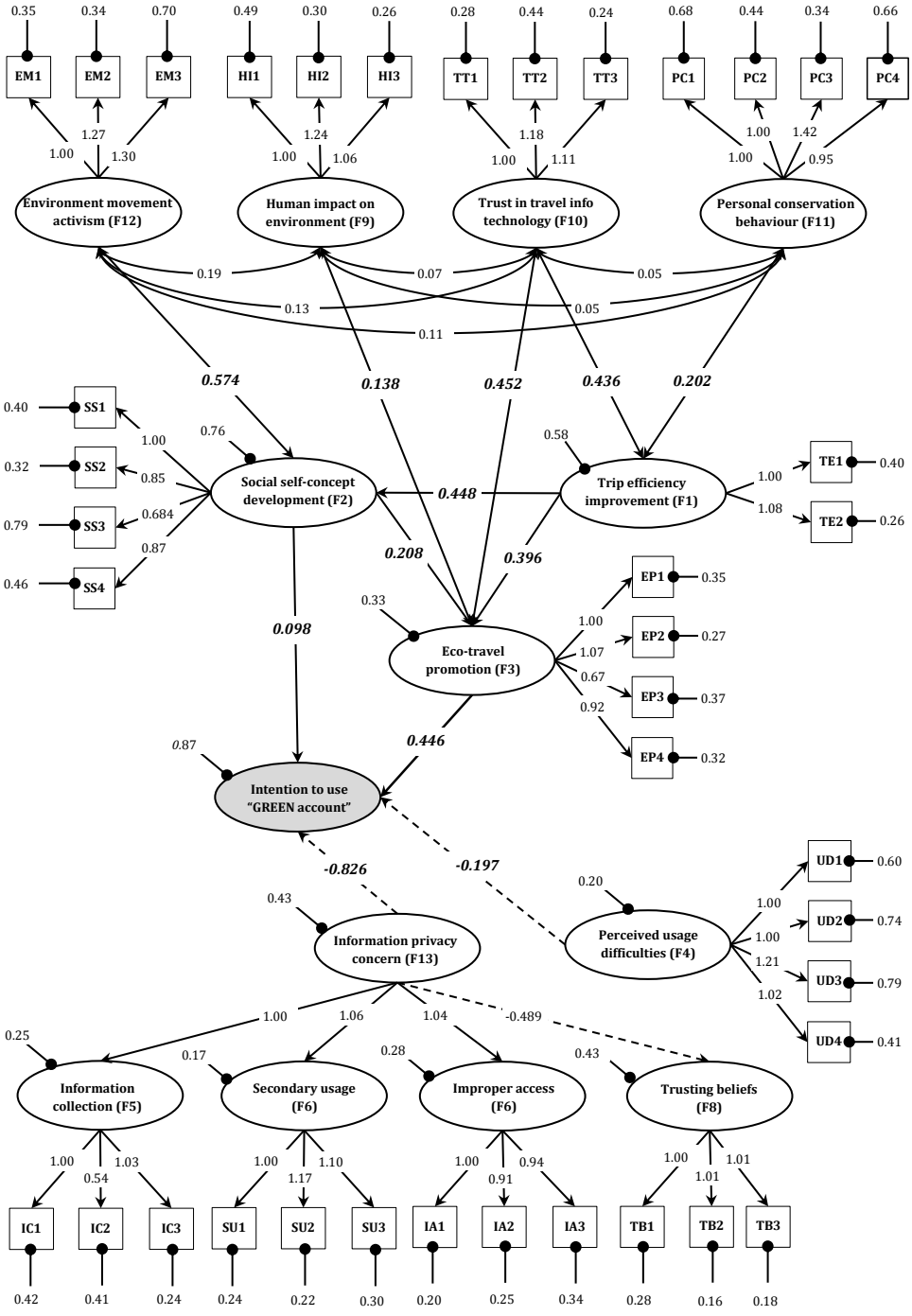


Figure 2-5 Full path diagram of the model

Note:

Positive relation ⟶ *Negative relation* - - - ➤ *Residual variance* ⟶● *Correlation* ⟷