Ex-ante and ex-post evaluation of a new transit information app: modelling use intentions and actual use

Guillermo Velazquez
PhD Candidate, Transport Research Centre (TRANSyT). Universidad Politecnica de Madrid
Prof Aranguren s/n 28040 Madrid, Spain
Tel: 0034 91 336 66 57 Email: g.velazquez@upm.es

Sigal Kaplan
Associate Professor, Department of Geography, Hebrew University of Jerusalem,
Mount Scopus 91905 Jerusalem, Israel
Tel: 02-5883020 Email: sigal.kaplan@mail.huji.ac.il

Andres Monzon
Professor. Universidad Politecnica de Madrid
Prof Aranguren s/n 28040 Madrid, Spain
Tel: 0034 91 336 5373 Email: andres.monzon@upm.es

Word count: 5,415 words text + 6 tables/figures x 250 words (each) = 6,915 words

Submission Date - 08/01/2017
Revised Submission Date - 11/15/2017
Final Submission – 13/03/2018
ABSTRACT

This study investigates the behavioral drivers underlying the adoption of a multimodal travel information mobile app. The hypothesized framework is validated empirically through the case-study of Madrid.

Madrid’s Public Transport real-time information app (“Mi Transporte”) allows users to obtain customized and automated information. A three-wave survey containing questions aligned with the Theory of Planned Behavior was conducted in 2015-2016 to a representative sample of transit users.

Data analysis includes a factor analysis and a structural equation model to validate the hypotheses. The model assumes that the intention to use the app can be explained as a function of attitudinal factors and respondent characteristics. Results show that the app adoption is correlated with the intention of the users to adopt it and with their willingness-to-pay; the users’ intentions can be explained by various factors like user’s expectations on the app, affinity for technology (technophilia) and the previous use of other transport apps. The roles of search functionalities, side-mode information, time saving skills and the importance of the Level of Service (LOS) are also analyzed in the model. Relations between user characteristics and latent variables are subsequently explained as well as the ex-post satisfaction and change in travel patterns to measure the impact on the transport behavior of the app users. The study provides a better understanding of app adoption based on traveler characteristics, the attributes of the app and the perception of its capabilities.

Keywords: Transit multimodal app, Structural Equations, app adoption, willingness-to-pay, behavioral model.
1 INTRODUCTION

As large centers of human and economic activity, modern metropolitan areas and mega-cities are characterized by population density and infrastructure design that define the urban efficiency level based on mobility and accessibility and considering the city area and the transport infrastructure by mode. While more than half a century ago, people agreed that cities have the capacity to extend, it is now becoming clearer that this capacity is becoming exhausted. Thus, the only viable solution for sustainable and competitive urban environments is to increase the mobility efficiency provided by the existing supply while maintaining regional growth. To enhance the efficiency of modern cities on the basis of the existing infrastructure, travelers must have the ability to combine different means of transport, adapting their choices to their circumstances as well as to the city context, and multi-modal transport systems need to operate as integrated, seamless networks. Multimodal trips have increased steeply in recent years, being one of the objectives of the European Commission for the future mobility of the EU’s urban areas in the phenomenon of automobile traffic saturation (Peak Car) and evidence to generation Y and Z becoming multimodal in several countries Northern Europe. Rethinking travel efficiency in the digital age, new ICT solutions have been introduced to enhance integration between modes at the information level. There is a proven positive impact of improved transit information on urban economy, mobility and environment as it results in more efficient journeys for individual travelers, and improved satisfaction with the service (25). Moreover, Ibraeva and Sousa (15) pointed out that the lack and/or complexity of information about routes and timetables serve as powerful barriers for potential transit use. Thus providing easily accessible and trustful information sources is essential for enhancing transit use as low-carbon mode and increasing its emission and fuel consumption efficiency per passenger trips. While information technology is relatively cost-efficient and their use is spreading rapidly among transport users, the development of ICT solutions is rarely financially supported by transport authorities and operators, likely because the effective reach of mobile technologies and impact on the travel patterns are yet unclear. Understanding the relation between real time information systems and transit use could support transit operators in their decision to invest in advanced information systems.

Objective measurable indicators support a positive relationship between information provision and transit ridership as the outcome. Interestingly, information still plays a minor role in modal choice when compared to journey planning and execution for a chosen mode (18). Today individuals still have to make their travel decisions under uncertain circumstances with respect to travel time; they are not able to predict the exact travel time or arrival time before starting their trips given a departure time (20), this uncertainty increases in the case of multimodal chains. Yet, studies show the potential of travel information systems to change travel patterns as a result of travel time savings (26), reducing travel time variability (11) and the increasing user satisfaction (10). While little research addressed the link between information and transit use, studies show a positive relationship between transit information and ridership (14), (5), (9) the same as for cycling (23). Therefore, the use of adequate channels to reach both active and potential users with information could be an important policy instrument. The utility of travel information provision becomes tangible in the users’ Willingness-To-Pay (WTP) for travel information, as demonstrated for example in Greece, the UK and China (31). Users are willing to pay for information that provides added value compared to existing information services (22) and that the most valued feature is real-time provision (8).

This research provides new insights regarding the willingness to adopt smartphone-based travel information apps. Until recently, pre-trip information could either be gathered at home or
on-route at designated locations (transit stops, vehicles etc.) now travelers carry their information source as they go along and the real-time information is continuously updated during the trip.

Precise spatial-temporal information at any time, any place about every transport mode could be a game changer because it allows travelers to plan, change, re-schedule and chain trips spontaneously and 'on the go'. This advantage may greatly facilitate multimodal and sustainable travel modes. The general increase in market penetration rates of mobile devices from developing to the most advanced economies, equipped with user interfaces, suggests that smartphones could serve as global opportunity in user-operator communication. Transport authorities have nowadays the opportunity to better integration of transport modes, facilitate multimodal transport choices in an effective and cost-efficient way by a simple to use push-button app. Mobile applications appear as a new solution to tackle these information provision problems, presenting travelers with a personalized set of modal options that can include soft aspects like comfort or convenience, which can be determinant for a modal change (18). Khattak et al. (19) found that individuals are more willing-to-pay for travel information via the telephone when the information is customized, their trips are longer, and the trip is related with work. The actual adoption of these mobile travel information apps is crucial for their deployment and improvement. In situations involving new technologies, intentions to use form a rigorous measure of future use behavior.

This study uses a three-waves panel survey to investigating the actual use of a new app throughout the two years research period. The Extended Technology Acceptance Model (ETAM) served as the behavioral framework for data analysis, further elaborated from previous studies by linking technology orientation, willingness-to-pay, user characteristics and perceptions. Doing so, this study extends existing knowledge both on app adoption (29) and regarding its usability (4). Up to now, little attention has been paid to the role of behavioral constructs in the association between expectations, intention to use the new information system, the willingness-to-pay and the actual adoption of mobile public transportation apps. Regarding the scope, the research analyses the latent constructs and variables related to user adoption of a new multimodal real-time information app for public transport in Madrid. In the following section the applied methods are described: experimentation plan, proposed behavioral framework and mathematical model. Then the case study of “Mi Transporte” app is introduced. Finally, the analysis results and conclusions are presented. The study adds to previous studies by validating the hypothesized behavioral framework and the structural relations among variables for the case study of Madrid (Spain).
2. METHODOLOGY, IMPLEMENTATION AND ANALYSIS

Madrid is characterized by a highly integrated and well-structured multi-modal transit system, where over one third of total daily trips are carried out on public transit and with a user base with high technophile. However, until recently there was no single official channel integrating real time information from the various transportation modes available to citizens (urban bus, metro, interurban bus, railway, walking). In May 2016, Madrid implemented its first official Public Transport real-time information app ("Mi Transporte" http://www.crtm.es/atencion-al-cliente/area-de-descargas/apps/app-tiempo-real.aspx ). Many cities have already done so, e.g. the apps developed by Transport for London, the Paris Region or Singapore on the public side, or the opening of data to the private sector that has developed apps in cities like San Francisco, Boston or London. “Mi Transporte” provides general information, such as the nearest stops, line routes, arrival times and trip disruptions, as well as the possibility for the user to obtain customized or automated information.

2.1. Hypothesized Behavioral Framework

The methodological procedure for the study starts with the development of hypothesis on the behavioral framework underlying the adoption of a transit mobile app. A survey is then designed, taking into account the needs of the model, to gather the relevant information on a representative sample of potential app users. The hypothesized behavioral model structure has been statistically tested and validated through a mathematical model. For our study, Structural Equation Models (SEM) were applied. SEM are a well-established and widely-applied method in behavioral, social and natural sciences, they allow not only to parameterize correlations among variables but to fully understand them in order to introduce improved policy recommendations.

We hypothesize that the use of the app is related to the willingness-to-pay for the app and the interest in trying it. This interest is motivated by personal technology affinity (technophilia), time saving skills, environmental responsibility, perceived importance of the level-of-service (LOS) and satisfaction with interchanges (the study was performed in one main interchange station), information search needs on transit, bicycle and car, and expectations regarding the benefits of the app. All of these elements were addressed in the questionnaire through specific sets of items.

The proposed behavioral framework is based on the Extended Technology Acceptance Model (ETAM), adapted to the context of transit use and mobile app use. In the ETAM, the demonstrability of the results and the output quality explain the perceived technology usefulness of the app which is expressed in terms of time and monetary savings. Subjective norms have not been considered as the usage of the app is not visible for other users. User experience or familiarity has been considered through the previous usage of mobility apps and the familiarity with technological devices. The construct of job relevance in the ETAM is a contextual variable and hence irrelevant in the current app use context. Hence, the proposed model framework enables to explore the following hypotheses:

H1: app use is related to the willingness-to-pay for the app and the intention to use it.
H2: user’s expectations, technophilia, and previous use of transport apps explain the intention to adopt the app.
H3: the search functionalities of the app, the LOS importance, information about side-modes and time saving skills explain the user's expectations.
H4: gender, age and smartphone use explain user’s technophilia.
H5: trip type (frequency, duration, reason of trip) and smartphone use are related to time saving skills.

2.3. Structural Equations Mathematical Model (SEM)
SEM presents a general statistical approach for validating a multivariate correlation structure across latent and observed variables in a series of equations. SEM is a generalization of regression that has an advantage in accommodating (i) a correlation structure across multiple dependent variables, and (ii) conceptual (latent) constructs that cannot be perfectly measured by a single observed indicator, but require multiple indicators. SEM is commonly viewed as a combination of confirmatory factor analysis (CFA), representing the relationship between the latent constructs and the set of observed indicators, and path analysis representing the dependency structure across the latent constructs (24). A growing number of recent studies applied SEM to explore mode choice and mode switching intentions of adults (7); (16); (17). The methodology is thoroughly presented by Pugeshk et al. (24), and its application in travel behavior research has been reviewed by Golob (12). In this study structural equations are used to explain the intention to use the app as a function of attitudinal factors and observed respondent characteristics.

The commercial software M-Plus served for the model estimation. The parameters were estimated simultaneously by using Maximum Likelihood with Huber-White covariance adjustment (30). Standard errors were calculated by adopting the White’s sandwich-based method that produces robust statistics in the presence of non-normality of the indicators and the categorical variables (28) (3) (6).

2.2. Survey Design and Administration
A survey was conducted along years 2015-2016 in order to investigate the relevant variables affecting the attractiveness and acceptance of the app. To obtain a representative sample of transit users (potential app users) we applied a mix survey methodology based on a personal intercept short interview combined with a web-based survey, technique tested by Hernandez, et al. (13). More than 2,000 public transport users of different ages, using different transportation modes and at different days of the week and hours of the day were intercepted and asked some questions and to fill in the online survey. Those completing the web questionnaire entered a price draw as incentive. They were intercepted in Avenida de America, one of the main interchange stations of the city that combines four subway lines (one circular line and three others), eleven urban bus lines, and twelve inter-urban bus lines, as well as park and ride facilities, with a demand of approximately 170,000 travelers per day.

The questionnaire was focused on five aspects: (i) use of Public Transit, (ii) use of technological devices, (iii) Perceptions on PT and on PT apps, (iv) willingness-to-pay for an app with certain characteristics (those to be introduced) and characteristic rating (WTP) and (v) user socioeconomic characteristics. It was a panel survey conducted in three waves. The survey constituted mainly of questions associated to the Theory of Planned Behavior that states that attitudes toward behavior, subjective norms, and perceived behavioral control, together shape an individual's behavioral intentions and behaviors (1). Further elements of the online survey and the survey methodology have been based on the practice of social research (2). The questions were rated on a 5-point scale from “strongly disagree” to “strongly agree”. The questionnaire design
including both positively and negatively phrased items, reverse-scoring is employed as the standard procedure in data analysis in order to combine the negatively and positively phrased items.

The survey included items addressed at observing the users’ characteristics on travel behavior, technological skills and predisposition to adopt both new technological solutions in general and mobile apps in particular. Completed by a set of questions on the users’ preferences for a transportation mobile app, as well as on their willingness to pay for such an application. In total 386 people answered to the ex-ante survey and 153 remained through the whole panel study.

**FIGURE 1. Panel Survey Evolution through the three waves**

Wave 1 (ex-ante) selected the users distributed by the different sample categories, before the app ‘Mi Transporte’ was launched. Wave 2 was carried out one month after the app was put in use. That means that users had started to get used to it and to realize its utility. Finally, the 3rd wave intended to capture changes in travel behavior and the assessment of the value added by the app.

**3. CASE STUDY: MADRID**

Madrid is a city of some 3.5 million inhabitants with its metropolitan area reaching 6 million covering a land-developed area of 1,037 km². Three ring motorways surround the city (M-30, M-40 and M-50) connecting seven radial motorway access. It has five fully operational (out of seven projected) multimodal interchange stations that connect the main accesses to the city with the public transportation network. According to the Household Mobility Survey of Madrid Region (CRTM, 2014) about 5 million displacements on public transport occur on a working day in the whole metropolitan area. This fact gives an idea of the importance of public transport management in the city and metropolitan area. Madrid Public Transport Authority (CRTM) manages 700 regional bus lines, 400 urban bus lines, 12 railway lines, 16 metro lines as well as six light rail lines. Within Madrid two thirds of daily trips are carried out in sustainable modes, half of them in public transit and the other half by walk.

Madrid City as well as CRTM are improving sustainable mobility by further enhancing public transportation and multimodality. Madrid City introduced in 2015 a new public bike-sharing system (BiciMAD) in the central area of the city which has kept constantly growing in area coverage and users. In this line CRTM is also working on new solutions that exploit their operation data in order to improve the information services provided to the users and to reduce user uncertainty associated to route planning and to disruptions in the service by unexpected incidents.

Regarding information provision the main public transport operators have launched in recent years information channels. Madrid city-bus (EMT) and Metro companies launched their real time information apps both available on the web from 2014 and for mobile devices from 2016 but they are not integrated. Also in 2015-2016 EMT installed panels providing real time information about next services at each bus stop. Metro did the same at station entrances and platforms. At multimodal level, both Madrid City and CRTM launched their Open Data portals containing real time as well as historic transit data for developers to integrate such information in diverse solutions for PT users.

The app subject to this analysis has multimodal dimension, combining static and real time information about the transport supply offered by 40 different public transport operators in the
Madrid Metropolitan Area and City. It improves the communication of the information on the
transport network to the final users, helping them to find the closest stop, providing the next
train/bus arriving to that stop, informing about any disruption on their trip, etc.


4. RESULTS AND DISCUSSION

4.1. Sample characterization and technophilia

The survey involved a total of 200 women and 186 men. It was stratified in three age groups:
young (18-30, 24%), adults (30 to 45 years, 51%) and senior travelers (50-70 years, 26%). It is
worth mentioning that the most limiting group to be targeted in order to achieve a representative
sample were senior travelers, as they are less adroit in the use of technology. The travel behavior of
respondents was collected through dedicated survey questions related to their most frequent trip.
The results showed that a great share of intermodal trips characterizes the sample as expected, with
the combinations of Bus-Metro and Metro-Bus accounting for more than 63% of multimodal trips.

In order to know to what extent the users were comfortable with the use of different
technological tools, they were asked about both their current IT device usage and their proficiency
level in the use of each of the more broadly extended devices: PC, Smartphone, Tablet and GPS.
The results, included in table 1, show that technological penetration rates are high among public
transport users in Madrid. Some 78% use personal computers and up to 86% declared a
proficiency level; almost 84% are users of smartphones with the same rate stating a good or very
good proficiency use level.

TABLE 1. Technological capabilities of the sample by age

4.2 Exploratory factor analysis

The data analysis included exploratory and confirmatory factor analysis followed by a structural
equation model to empirically validate the framework. The objective of exploratory factor analysis
is to identify a set of latent constructs underlying a set of measured variables in a situation without
a-priori hypotheses, while confirmatory factor analysis is to test whether the data fit a
hypothesized measurement model. The exploratory factor analysis served to extract the latent
constructs among variables. Tests of internal consistency and sample adequacy constituted the
necessary preliminary conditions for conducting factor analysis and obtaining meaningful results.

The items obtained in the survey demonstrate good internal consistency (Cronbach's alpha
= 0.876) and good sampling adequacy according to Kaiser-Meyer-Olkin measure (KMO = 0.881).
The Spearman correlation matrix shows the existence of correlations without multi-collinearity.
The result of the Bartlett’s test of sphericity rejects the null hypothesis that the correlation matrix is
an identity matrix (p = 0.000). Exploratory principal axis factor analysis with varimax rotation
(Kaiser normalization) produced six or seven factors according to the Scree plot. The existence of
a factor that contained information on environmental concerns was deemed interesting for the
analysis and therefore seven factors were taken into account for the modelling. The interpretation
of the meaning of the factors rely on their supporting questions scored by the respondents. Thus,
the first factor (F1) has been labelled “Technophile”. The next factor (F2) “Expectations regarding
the app”, the third one (F3) is labelled “app search functionalities”. The next three factors were
labelled “Level Of Service (LOS) importance” (F4), “Side-mode information” (F5), and “Time
saving skills” (F6). Finally the last factor (F7) grouped “Environmental responsibility” items.
Then, those factors were confirmed by confirmatory factor analysis, then contrasted, associated to
user characteristics (e.g. age, gender, trip length and type, principle mode and smartphone use) and
introduced into the structural relation model. The analysis of the table 2 results shows the
explanatory power of the seven identified latent variables and the questions of the survey that
support the loading factors of each of them.
TABLE 2. Output of rotated factor analysis (exploratory)

4.3 Structural Equation Model estimation and results

The estimation results are presented in table 3 which presents the measurement equations of the confirmatory factor analysis that corresponds to exploratory factor analysis presented in table 2 in the previous section. In this study, the factor structure is revealed by exploratory factor analysis and it is used as part of the model structure with confirmatory factor analysis, which enhances the structural validity of the proposed model. The CFI value, which indicates the goodness-of-fit of the confirmatory factor analysis, is 0.835, showing excellent data fit. The model including the set of measurement and structural equations fits reasonably well.

The statistical model confirms the general behavioral framework and the research hypotheses for the case study of Madrid. Table 3 shows the relationship between the latent constructs and the respondents characteristics. Most importantly, we focus on the effect of the various latent constructs on the intention to use the real-time information app, as well as on the willingness to pay and the actual app use. The model statistically confirms H1 with the relation of willingness-to-pay for the app and the intention to use it being significant for its actual adoption. The statistical model also confirms H2. With the user’s expectations, the user’s technophilia, and his previous use of transport mobile apps explaining the intention to adopt the app. The statistical model confirms H3. User’s expectations are positively and significantly explained by search functionalities of the app, the LOS importance, information about side-modes and time saving skills. The correlation patterns on table 3 do confirm H4. With Gender and age negatively and significantly correlated (male and younger are more technophile) with the technophile factor and smartphone use positively and significantly correlated with the technophile factor (F1). The model also confirms H5 with the importance of Time Saving Skills positively and significantly related to the frequency and duration of the trip, as well as to the use of smartphone, while negatively and significantly related to the most frequent trip taking place inside the City Centre.

TABLE 3. Structural equations relating latent factors to app use intention and adoption

Finally, the analysis also showed that the importance of Side-Mode information is positively and significantly correlated to the Environmental responsibility factor, and that the importance of the LOS is explained by Age and Gender (female and elder give more importance to LOS). These results and the weights among interrelated factors are explained below and represented in figure 3.

FIGURE 3. Structural equations model: relation among variables and latent variables

The analysis of the SEM shows that (i) The adoption of the app is correlated with the user’s intention to adopt it and more strongly with the WTP; (ii) while the intentions can be explained by various factors, the WTP is only related to the WTP to save time; (iii) user’s expectations, technophilia, and previous use of transport apps strongly explain the intention to adopt the app; (iv) the search functionalities, the LOS importance, information about park-and-ride and bicycle and time saving skills explain the user's expectations; (v) Gender, age and smartphone use explain
user’s technophilia, (vi) trip type, frequency, duration and smartphone use are related to time saving skills.
6. CONCLUSIONS

“Mi Transporte” app has achieved a relative success. 35% of the users that tested it are using it frequently for their most frequent trip and 48% of them stated that the app is now their main mobility app. The app has changed for most (60%) their waiting time or route choice. The general rating and user knowledge on the app improved along the experimentation period, with no severe reliability issues being reported. The most important declared attributes are that the app is free, multimodal and provides information in real time. WTP is low, and always linked to tangible time savings thanks to the use of the app.

Model results expand the body-of-knowledge from the mere analysis of attitudes to a wider scope that considers user characteristics, perceptions and behavior. As hypothesized user’s expectations, technophilia, and previous use of transport apps explain the intention to adopt the app. The expectations are explained by search functionalities of the app, LOS importance for the user, availability of side-mode information and user’s time saving skills. The model also explains the actual adoption of the app, as related to WTP and the intention to use it.

These results provide researchers and practitioners with a better understanding of the use of mobile app solutions by transit users and shed light on potential elements to be considered for the implementation of transit app technologies by cities for them to achieve their maximum potential linked to personalized services offering (Mobility as a service). We have attempted to reduce potential biases, e.g. by using the appropriate statistical methods, but we recognize that certain biases inherent in survey research, such as self-selection and policy response bias, may remain.

Future research lines include analyzing the effect of transit use frequency on app adoption and WTP or studying the underuse of features like automation of reiterative searches or personalized alarms revealed by the ex-post analysis in comparison to the declared interest in the ex-ante survey.

Acknowledgements
The authors gratefully acknowledge that the data employed for the study are part of the Madrid Pilot Case coordinated by Madrid Public Transport Authority (CRTM), for the project OPTICITIES (www.opticities.com), funded by the European Commission under the 7th Framework R&D Programme.

The authors confirm contribution to the paper as follows: study conception and design: Guillermo Velázquez, Sigal Kaplan, Andrés Monzón; data collection: Guillermo Velázquez, Andrés Monzón; analysis and interpretation of results: Guillermo Velázquez, Sigal Kaplan, Andrés Monzón; draft manuscript preparation: Guillermo Velázquez. All authors reviewed the results and approved the final version of the manuscript.

REFERENCES


21. Loehlin, JC and Beaujean, AA. Latent variable models: an introduction to factor, path, and structural equation analysis.


LIST OF FIGURES AND TABLES

FIGURE 1. Panel Survey Evolution through the three waves
FIGURE 3. Structural equations model: relation among variables and latent variables
TABLE 1. Technological capabilities of the sample by age
TABLE 2. Output of rotated factor analysis (exploratory)
TABLE 3. Structural equations relating latent factors to app use intention and adoption
FIGURE 1. Panel Survey Evolution through the three waves

1. Ex-ante (before)
   - Travelers’ needs
   - Previous mobility profile
   - APP expectations
   - Willingness to pay

   Intention to use: 56%

2. In-itinere (month 1)
   - Installation problems?
   - Easy to use?
   - First impression

   Actual use: 33%

3. Ex-post (month 6)
   - Changes mobility profile
   - App’s use and assessment
   - Willingness to pay

   Actual use: 34%
TABLE 1. Technological capabilities of the sample by age

<table>
<thead>
<tr>
<th></th>
<th>15-30 year old</th>
<th>30-50 year old</th>
<th>50-65 year old</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>89.3%</td>
<td>82.9%</td>
<td>73.3%</td>
<td>83.7%</td>
</tr>
<tr>
<td>PC</td>
<td>80.3%</td>
<td>76.3%</td>
<td>76.0%</td>
<td>78.0%</td>
</tr>
<tr>
<td>Tablet</td>
<td>44.0%</td>
<td>49.3%</td>
<td>32.0%</td>
<td>43.8%</td>
</tr>
<tr>
<td>GPS</td>
<td>20.1%</td>
<td>27.6%</td>
<td>26.7%</td>
<td>24.4%</td>
</tr>
</tbody>
</table>
1 | **TABLE 2. Output of rotated factor analysis (exploratory)**

<table>
<thead>
<tr>
<th>Item</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like to try new technological devices</td>
<td>.766</td>
<td>.154</td>
<td>.195</td>
<td>.099</td>
<td>.023</td>
<td>.119</td>
<td>.027</td>
</tr>
<tr>
<td>I believe that new technologies have great potential</td>
<td>.664</td>
<td>.115</td>
<td>.252</td>
<td>.074</td>
<td>-.120</td>
<td>-.017</td>
<td>.053</td>
</tr>
<tr>
<td>I'm interested in new technologies</td>
<td>.802</td>
<td>.153</td>
<td>.194</td>
<td>.044</td>
<td>-.024</td>
<td>.095</td>
<td>.027</td>
</tr>
<tr>
<td>I like to renew my mobile from time to time to keep it updated</td>
<td>.572</td>
<td>.128</td>
<td>-.045</td>
<td>.050</td>
<td>.093</td>
<td>-.033</td>
<td>.117</td>
</tr>
<tr>
<td>apps help me in my daily life</td>
<td>.720</td>
<td>.238</td>
<td>.068</td>
<td>.032</td>
<td>.086</td>
<td>.016</td>
<td>.048</td>
</tr>
<tr>
<td>I need technological tools in my daily life</td>
<td>.703</td>
<td>.088</td>
<td>.008</td>
<td>-.073</td>
<td>.076</td>
<td>.057</td>
<td>.043</td>
</tr>
<tr>
<td>Some apps are fun to use</td>
<td>.674</td>
<td>.151</td>
<td>.102</td>
<td>.138</td>
<td>.011</td>
<td>.006</td>
<td>.117</td>
</tr>
<tr>
<td>I like to find new applications</td>
<td>.773</td>
<td>.195</td>
<td>.076</td>
<td>.100</td>
<td>-.007</td>
<td>.041</td>
<td>.099</td>
</tr>
<tr>
<td>Please indicate your level of skills in the usage of Tablet devices</td>
<td>.580</td>
<td>.131</td>
<td>.257</td>
<td>.026</td>
<td>.093</td>
<td>.294</td>
<td>-.325</td>
</tr>
<tr>
<td>Please indicate your level of skills in the usage of Smartphone devices</td>
<td>.610</td>
<td>.087</td>
<td>.198</td>
<td>.089</td>
<td>.034</td>
<td>.202</td>
<td>-.264</td>
</tr>
<tr>
<td>Please indicate your level of skills in the usage of Laptop devices</td>
<td>.517</td>
<td>.128</td>
<td>.297</td>
<td>-.019</td>
<td>.054</td>
<td>.295</td>
<td>-.294</td>
</tr>
<tr>
<td>Please indicate your level of skills in the usage of GPS devices</td>
<td>.517</td>
<td>.011</td>
<td>.153</td>
<td>.062</td>
<td>.252</td>
<td>-.248</td>
<td>-.198</td>
</tr>
<tr>
<td>Please indicate the importance of each of the following criteria for your MOST FREQUENT TRIP.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>.135</td>
<td>-.018</td>
<td>.005</td>
<td>.601</td>
<td>.078</td>
<td>.202</td>
<td>-.132</td>
</tr>
<tr>
<td>Flexibility</td>
<td>.111</td>
<td>.103</td>
<td>.122</td>
<td>.727</td>
<td>-.005</td>
<td>-.059</td>
<td>.117</td>
</tr>
<tr>
<td>Predictability</td>
<td>.147</td>
<td>.035</td>
<td>.103</td>
<td>.570</td>
<td>-.113</td>
<td>.120</td>
<td>.025</td>
</tr>
<tr>
<td>Safety</td>
<td>-.004</td>
<td>.127</td>
<td>.069</td>
<td>.540</td>
<td>-.064</td>
<td>-.025</td>
<td>-.022</td>
</tr>
<tr>
<td>Security</td>
<td>-.014</td>
<td>.061</td>
<td>.068</td>
<td>.593</td>
<td>-.071</td>
<td>-.066</td>
<td>-.066</td>
</tr>
<tr>
<td>Comfort</td>
<td>.025</td>
<td>.120</td>
<td>.039</td>
<td>.674</td>
<td>.098</td>
<td>.073</td>
<td>.033</td>
</tr>
<tr>
<td>Pleasure</td>
<td>-.074</td>
<td>.159</td>
<td>-.052</td>
<td>.654</td>
<td>.118</td>
<td>-.145</td>
<td>.160</td>
</tr>
<tr>
<td>Capability to carry items</td>
<td>.071</td>
<td>.047</td>
<td>.064</td>
<td>.569</td>
<td>.067</td>
<td>-.020</td>
<td>.269</td>
</tr>
<tr>
<td>My most frequent trip takes too much time</td>
<td>.090</td>
<td>-.064</td>
<td>.096</td>
<td>.045</td>
<td>-.009</td>
<td>.681</td>
<td>.017</td>
</tr>
<tr>
<td>I feel like I waste my time on the way</td>
<td>.049</td>
<td>-.042</td>
<td>-.016</td>
<td>-.081</td>
<td>.019</td>
<td>.694</td>
<td>-.101</td>
</tr>
<tr>
<td>I would use public transport more often if there was real-time service information</td>
<td>.136</td>
<td>.151</td>
<td>-.076</td>
<td>.119</td>
<td>-.050</td>
<td>.510</td>
<td>.361</td>
</tr>
<tr>
<td>I would use public transport more often if the service was better</td>
<td>.080</td>
<td>.027</td>
<td>-.089</td>
<td>.116</td>
<td>.042</td>
<td>.714</td>
<td>.264</td>
</tr>
<tr>
<td>The impact of transport on the environment is a real problem in Madrid</td>
<td>-.018</td>
<td>.015</td>
<td>.123</td>
<td>.014</td>
<td>.027</td>
<td>.238</td>
<td>.681</td>
</tr>
<tr>
<td>I feel as part of my responsibilities to reduce the emission of pollutants that potentiate the greenhouse effect</td>
<td>-.000</td>
<td>.082</td>
<td>.000</td>
<td>.123</td>
<td>.068</td>
<td>.058</td>
<td>.786</td>
</tr>
<tr>
<td>It's important to search for the name of the stop</td>
<td>.199</td>
<td>.151</td>
<td>.517</td>
<td>.079</td>
<td>-.045</td>
<td>.084</td>
<td>.033</td>
</tr>
<tr>
<td>It's important to find the nearest stop of a chosen line</td>
<td>.113</td>
<td>.202</td>
<td>.723</td>
<td>.073</td>
<td>.082</td>
<td>-.011</td>
<td>.038</td>
</tr>
<tr>
<td>It's important to find the nearest stop of a chosen mode of public transport</td>
<td>.139</td>
<td>.106</td>
<td>.800</td>
<td>.052</td>
<td>.081</td>
<td>-.034</td>
<td>.061</td>
</tr>
<tr>
<td>It's important to find the nearest public transport stop</td>
<td>.061</td>
<td>.063</td>
<td>.758</td>
<td>.080</td>
<td>.117</td>
<td>.032</td>
<td>-.005</td>
</tr>
<tr>
<td>It's important to find the nearest BiciMAD station</td>
<td>.063</td>
<td>.186</td>
<td>-.011</td>
<td>.020</td>
<td>.790</td>
<td>.013</td>
<td>.103</td>
</tr>
<tr>
<td>It's important being able to search for nearby BiciMAD stations according to occupancy level</td>
<td>.075</td>
<td>.194</td>
<td>-.010</td>
<td>.015</td>
<td>.789</td>
<td>-.063</td>
<td>.073</td>
</tr>
<tr>
<td>It's important being able to find deterrent parking facilities (and information on public transport services there)</td>
<td>.111</td>
<td>.067</td>
<td>.116</td>
<td>-.009</td>
<td>.802</td>
<td>.009</td>
<td>.008</td>
</tr>
<tr>
<td>It's important to be able to search for parking facilities according to occupancy level</td>
<td>.121</td>
<td>.018</td>
<td>.097</td>
<td>.049</td>
<td>.795</td>
<td>.033</td>
<td>-.003</td>
</tr>
<tr>
<td>If the app allows me to save travel time, I intend to use it in my daily trips</td>
<td>.316</td>
<td>.595</td>
<td>.445</td>
<td>.113</td>
<td>-.036</td>
<td>.103</td>
<td>.005</td>
</tr>
<tr>
<td>If the app can increase the predictability of my daily trips, I will use it</td>
<td>.270</td>
<td>.574</td>
<td>.438</td>
<td>.169</td>
<td>-.080</td>
<td>.039</td>
<td>-.052</td>
</tr>
<tr>
<td>If the app allows me to save money, I intend to use it</td>
<td>.302</td>
<td>.569</td>
<td>.475</td>
<td>-.022</td>
<td>-.102</td>
<td>.100</td>
<td>-.041</td>
</tr>
<tr>
<td>If the app allows me to plan my trips better, I intend to use it</td>
<td>.291</td>
<td>.565</td>
<td>.432</td>
<td>.036</td>
<td>-.039</td>
<td>-.034</td>
<td>-.031</td>
</tr>
<tr>
<td>Using the app will allow me to save some travel time</td>
<td>.143</td>
<td>.788</td>
<td>.100</td>
<td>.119</td>
<td>.022</td>
<td>.012</td>
<td>.013</td>
</tr>
<tr>
<td>Thanks to the app I will get to my destination more calmly</td>
<td>.145</td>
<td>.800</td>
<td>.060</td>
<td>.038</td>
<td>.128</td>
<td>.002</td>
<td>.037</td>
</tr>
<tr>
<td>Thanks to the app I will improve the regularity in my times of displacement</td>
<td>.155</td>
<td>.783</td>
<td>.145</td>
<td>.150</td>
<td>.127</td>
<td>-.055</td>
<td>.009</td>
</tr>
<tr>
<td>Thanks to the app I will reduce the impact of my travels on the environment</td>
<td>.012</td>
<td>.593</td>
<td>.049</td>
<td>.003</td>
<td>.269</td>
<td>-.025</td>
<td>.333</td>
</tr>
<tr>
<td>I think using the app will make it easier for me to change my transport habits</td>
<td>.200</td>
<td>.691</td>
<td>-.168</td>
<td>.061</td>
<td>.165</td>
<td>.020</td>
<td>.079</td>
</tr>
<tr>
<td>I think the app will be easy to use</td>
<td>.319</td>
<td>.538</td>
<td>.186</td>
<td>.158</td>
<td>.012</td>
<td>.064</td>
<td>-.055</td>
</tr>
</tbody>
</table>

2 The factor loadings are presented in the table. In order to facilitate factor labeling, the dominant items, marked in bold, were defined as those with an absolute value of the loading greater than 0.50.
### TABLE 3. Structural equations relating latent factors to app use intention and adoption

<table>
<thead>
<tr>
<th>Latent Constructs</th>
<th>Explanatory / mediator variable</th>
<th>Est.</th>
<th>C.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-mode information (F5)</td>
<td>Environmental responsibility (F7)</td>
<td>0.873</td>
<td>2.954</td>
</tr>
<tr>
<td></td>
<td>app search functionalities (F3)</td>
<td>1.213</td>
<td>7.008</td>
</tr>
<tr>
<td>Expectations regarding the app (F2)</td>
<td>Los importance (F4)</td>
<td>1.204</td>
<td>4.450</td>
</tr>
<tr>
<td></td>
<td>Side-mode information (F5)</td>
<td>0.094</td>
<td>3.924</td>
</tr>
<tr>
<td></td>
<td>Time saving skills (F6)</td>
<td>0.327</td>
<td>2.580</td>
</tr>
<tr>
<td>Technophile (F1)</td>
<td>Age</td>
<td>-0.024</td>
<td>-3.776</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>-0.294</td>
<td>-1.622</td>
</tr>
<tr>
<td></td>
<td>Smartphone User</td>
<td>1.495</td>
<td>5.911</td>
</tr>
<tr>
<td>LOS importance (F4)</td>
<td>Age</td>
<td>0.006</td>
<td>2.411</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>0.201</td>
<td>3.001</td>
</tr>
<tr>
<td>Time saving skills (F6)</td>
<td>Smartphone User</td>
<td>0.187</td>
<td>1.331</td>
</tr>
<tr>
<td></td>
<td>Frequency of most frequent trip</td>
<td>0.073</td>
<td>1.816</td>
</tr>
<tr>
<td></td>
<td>Most Frequent Trip is long</td>
<td>0.255</td>
<td>1.485</td>
</tr>
<tr>
<td></td>
<td>Most Frequent Trip is Centre-Centre</td>
<td>-0.290</td>
<td>-2.315</td>
</tr>
<tr>
<td>Dependent Variables</td>
<td>Explanatory / mediator variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intention to use the app</td>
<td>Technophile (F1)</td>
<td>0.847</td>
<td>3.371</td>
</tr>
<tr>
<td></td>
<td>Expectations regarding the app (F2)</td>
<td>1.104</td>
<td>4.088</td>
</tr>
<tr>
<td></td>
<td>Previous app User</td>
<td>0.944</td>
<td>2.126</td>
</tr>
<tr>
<td>Willingness To Pay (WTP)</td>
<td>Willing to pay to save 40% or more of trip time</td>
<td>0.230</td>
<td>2.300</td>
</tr>
<tr>
<td>Use of the app</td>
<td>Willingness to Pay (WTP)</td>
<td>0.188</td>
<td>1.377</td>
</tr>
<tr>
<td></td>
<td>Intention to use the app</td>
<td>0.098</td>
<td>2.548</td>
</tr>
</tbody>
</table>

Ratio between chi-square and degrees of freedom = 2.42 which are good (27).
RMSEA stands at 0.072. CFI stands at 0.835, which are reasonable according to Loehlin et al. (21).
FIGURE 3. Structural equations model: relation among variables and latent variables