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Investigating the effects of platform and mobility on mobility as a service (MaaS) users' service experience and behavioral intention: empirical evidence from MeNGo, Kaohsiung

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Abstract
Different from most existing studies in the literature, this study proposes and empirically examines an integrated model to understand user experience and behavior based on actual experiences with a real-world MaaS platform. Specifically, the relationships among perceived service features (i.e. platform and mobility services), perceived value, satisfaction, and behavioral intention of existing MaaS users were examined using a survey sample of 363 existing MaaS users in Taiwan. Results reveal that the most important variable explaining intention to use MaaS is mobility benefits derived from using MaaS, more so than cost/economic benefits, access to greater information, and ease of transaction. MaaS operators need to prioritize service features that offer access to newer modes, more frequent services, covering greater network areas. While other measures such as discounted pricing, provision of dynamic and real-time information, integrated ticketing and payment are valuable, they are unlikely to prove popular with consumers unless the MaaS service can offer a substantial benefit in terms of access to new and expanded transport services. Implications and recommendations for future research are also discussed.

Keywords Mobility as a service (MaaS) · Platform · Mobility · Perceived value · Satisfaction · Behavioral intention

Introduction

Along with the growth of urban population, from 55.7% to 2019 to a forecast of 68% in 2050 by the United Nations (2018), the increasing demand for mobility services in urban areas will become an inevitable challenge to the quality of life and well-being for urban dwellers (Sochor et al., 2015; Van Audenhove, et al., 2014). Both transport impacts (e.g.,

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traffic congestion, shortage of parking spaces, and accidents) and environmental impacts (e.g., air pollution, greenhouse emissions, and noise) are foreseeable in addition to associated effects such as urban sprawl, social exclusion, and health issues. There is hence a necessity to call for effective, innovative, and sustainable mobility solutions to mitigate any negative avoidable consequences. Among smart mobility solutions based upon technological advancements, Mobility as a Service (MaaS) is one of the initiatives attracting increasing attention and gaining wider recognition in terms of addressing transport related issues in urban contexts (Matyas & Kamargianni, 2019; Schikofsky, Dannewald & Kowald, 2020).

MaaS aims to fulfill an individual's mobility needs in a sustainable way by combining different transport services to seamless trips (Utriainen & Pöllänen 2018). The idea is that the user does not need to own a car or a bike to be able to realize their daily mobility needs. In this model, trips can be prepaid (e.g., monthly basis mobility packages including wanted services) or trips can be paid individually (pay-as-you-go) (Kamargianni et al., 2016). The planning of trips and the payment are made by using a digital platform (Ho et al., 2018). A single application that enables the payment and integration of multiple transport modes benefits users compared to the current system, in which individuals are responsible for the integration of different transport modes with several ticket systems. The role of a MaaS operator is crucial, because the operator integrates different transport services, such as bikesharing, car-sharing, and taxis, that enable the whole concept to be more fluid (MaaS Global, 2016).

According to the framework proposed by Wong et al. (2020), the MaaS ecosystem consists of mobility broker, demanders, and suppliers with "the new function for a mobility broker aggregating different suppliers and delivering [an] integrated service to demanders" (Wong & Hensher, 2020, P.4). To meet people's mobility demand, the purpose of MaaS is to integrate mobility services through ICT into a single interface and provide seamless mobility service to users (Heikkila, 2014; Kamargianni & Matyas, 2017). MaaS provides not only a system where public transport service can be integrated with other on-demand and shared services such as ride-sharing, bike-sharing, and car-sharing, but is also a single online interface (platform) utilized for payment, journey planning, and other traveler information through ICT technology (Liljamo, Liimatainen, Pöllänen & Utriainen, 2020; Sochor et al., 2015; Hensher et al., 2017; Utriainen & Pollanen, 2018).

There are five main featured integration services of MaaS: (1) provision of a discounted subscription, (2) ticket integration, (3) payment integration, (4) ICT integration, and (5) customized mobility services (Kamargianni et al., 2015). By integrating various real-time traffic information through ICT technology, MaaS operators can propose an ideal travel chain, including route planning to destinations (Kamargianni & Matyas, 2017). MaaS sells mobility services in general through packages or subscriptions, and passengers can choose the most suitable solution based on their own needs. Hence, this innovative mobility service is anticipated to achieve local and national social goals - namely, reducing the number of private cars, increasing the use of shared resources, and lowering the environmental impact of transportation (Sochor et al., 2015). Different from traditional public transport services, a MaaS broker functions as the role of mobility intermediary (Lyons et al., 2019) and not only provides a mobility information platform, but also a mobility service package for users.

The few existing MaaS programs under operations as prominent examples mainly appear in European cities, including UbiGO (http://www.ubigo.se/) in Gothenburg/ Stockholm, and Whim (https://whimapp.com) in Helsinki/Birmingham/Antwerp. In Asian cities, MeN GO (https://www.men-go.tw) has notably been implemented in Kaohsiung City, Taiwan since

2018 and is the only one program operating with success in the country. Focusing on the European MaaS programs, Sochor, Strömberg, and Karlsson (2014) examined travelers' motives for adopting the UbiGo field operational test, and Hartikainen et al. (2019) reported an impact assessment of Whim, the world's first MaaS system. Because MaaS programs are scarce, previous studies on MaaS mainly cast light into its conceptual configurations and associated benefits (Esztergar-Kiss & Kerenyi, 2020; Lyons et al., 2019) and business model (Wong & Hensher, 2020) or explore users' adoption intentions (Ho, Mulley, & Hensher, 2020; Liljamo et al., 2020; Schikofsky et al., 2020; Polydoropoulou, Pagoni, & Tsirimpa, 2020). Lyons et al. (2019) classify five integration levels of MaaS based upon the Levels of MaaS Integration (LMI) from users' perspective and develop MaaS behavioral schema to discuss individuals' adoption intention. Esztergar-Kiss & Kerenyi (2020) discuss what it is and how to design a suitable mobility package for MaaS users. Schikofsky et al. (2020) investigate the adoption motivation of MaaS by interviewing potential users. Wong & Hensher (2020) examine the delivery of MaaS through a broker/aggregator business model, whereby the design and implementation of MaaS are constructed by the three Bs: budgets, bundles, and brokers. Liljamo et al. (2020) present people's views on key aspects related to MaaS as well as their willingness to pay for MaaS in terms of absolute value and the relative value to their current mobility costs by using a survey conducted in Finland.

To our best knowledge, studies going beyond adoption intention and investigating users' perceptions of MaaS service configurations, service evaluations, and behavioral intention from the perspective of actual use experience are still rare except recent research evidence from Trippy trial in Sydney (e.g. Hensher, Ho, & Reck, 2021; Ho, Hensher & Reck, 2021; Ho et al., 2021). Findings from the Trippy trial in Sydney provide insights into the interest in various MaaS subscription plans (Ho, Hensher & Reck, 2021), the effect of monthly mobility bundle on use change of private car (Hensher, Ho, & Reck, 2021), and how to design successful bundles to attract MaaS users (Ho et al., 2021). Insights gained from MaaS users' behaviors and their affecting factors can help improve the service delivery of a current operating scheme as well as facilitate the implementation progress of MaaS programs in various cities across the world. To fill this research gap, the present study draws upon the service quality-value-satisfaction-behavioral intention framework in the service literature (Cronin et al., 2000) and empirically investigates the relationships among MaaS service quality, perceived value, satisfaction, and behavioral intention via a survey sample of MeNGo users in Kaohsiung, Taiwan. Considering platform and mobility as the two major components of a MaaS program, we specifically identify their dimensions of service configurations for each component for further analysis within the service quality-value-satisfaction-behavioral framework. The proposed model is shown as Fig. 1.

Theoretical background and hypotheses

Theoretical background

Since this study aims to investigate service evaluations and their effects on behavioral intention from actual use experience, we focus on related service evaluation metrics such as service quality, service value, and satisfaction and their inter-relationships, which have dominated the services literature (Cronin et al., 2000). Previous public transport related studies

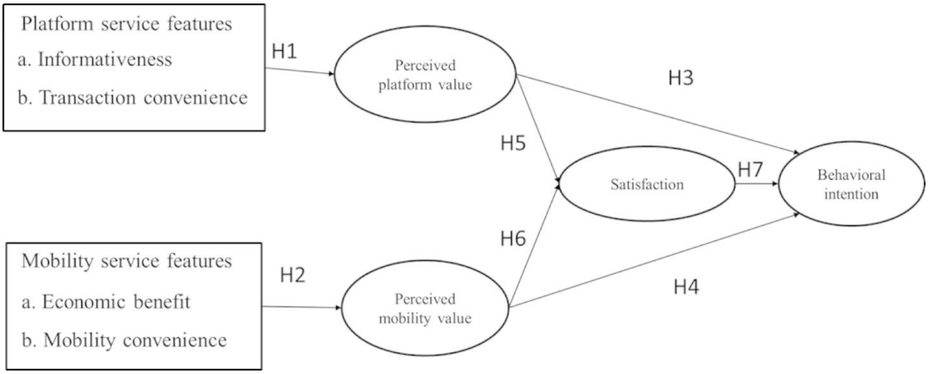

Fig. 1 Conceptual model

have provided evidence for the most common determinants affecting customer loyalty (or post-purchase behavioral intention) such as perceived service quality, perceived value, and satisfaction (Su, Nguyen-Phuoc, & Johnson, 2021; De Ona et al., 2013; De Ona et al., 2015; Lai & Chen, 2011; Chen et al., 2021). According to the service quality-perceived value-satisfaction-behavioral intention framework (Cronin et al., 2000), service quality (the initial cognitive service evaluation) and value appraisal lead to an emotional reaction such as satisfaction that subsequently drives behavioral intention or actual behavior, which relates to customer loyalty in a service context. Adapting the framework to the MaaS service context suggests that users' perceived service quality from the MaaS encounter directly impacts their value appraisals, which lead to their satisfaction and in turn behavioral intention.

Previous studies (Lai & Chen, 2011, De Oña et al., 2013, De Oña et al., 2015; Zhang et al., 2019) suggest that improving and providing a quality public transport service are important for public transport to become competitive with private vehicles. As suggested by "mobility as a service", MaaS provides users access to transport services via mobile apps (Alyavina et al., 2020). From the user perspective, the service delivery of MaaS consists of two kinds of service features: platform and mobility service.

Perceived MaaS platform quality

The platform of MaaS can be identified by two key features: informativeness and transaction convenience. Informativeness pertains to a composite of the quality and trustworthiness of information provided by the platform; i.e., the extent to which a platform provides useful and helpful information to users (Luo, 2002). Informativeness is viewed as a requirement for the platform of a successful MaaS. The MaaS platform should be able to easily access open data like timetables of transport and real-time location of public transport, integrate them on an app/web (Mulley et al., 2018), and provide both transport information and tourist information (Ho et al., 2018; Kamargianni & Matyas, 2017). Transaction convenience relates to the perception of time and effort spent by the customer during a transaction (Berry et al., 2002). The MaaS platform integrates the ticket and payment of transportation services (Kamargianni et al., 2015) to make a transaction more convenient and to reduce any transaction hassle such as removing the time-consuming action of one-off payments for an individual mobility provider (Mulley et al., 2018).

Perceived mobility service quality

The mobility aspect of Maas involves quality dimensions such as economic benefit, seamlessness, perceived accessibility, and flexibility that users expect to experience from an integrated transport service. The economic benefit relates to monetary savings or price reductions consumers obtain through a specific product or service purchase such as MaaS (Lyons, et al., 2019; Sochor, et al., 2015), hence indicating the price value of using MaaS service. Seamlessness, defined as "the extent that [it] integrates different public transportation systems to reach the purpose of door-to-door service" (Cheng & Chen, 2015) is the main MaaS service feature to meet users' demand of multi-transport modes and expand public transport's performance. Perceived accessibility pertains to "the extent that users live a satisfactory life easily with the help of the transportation system". MaaS integrates multiple mobility services that can take travelers from one place to another easily, thus increasing public transport accessibility. The integrated mobility services of Maas provide users more transport alternatives to use (choose) and thus increase their flexibility (Sochor, et al., 2016).

Perceived value

Perceived value of service consumption pertains to a consumer's overall assessment of the trade-off between what is received (perceived benefits) and what is given (perceived costs) (Lovelock, 2000). While the benefits associated with service features can be obtained through service consumption, users have to give their own resources such as money, time, and effort. Consumers' value perception of a product (or service) plays an important role in determining their satisfaction, loyalty, and future behaviors such as purchase intention and willingness to buy (Chen & Huang, 2021; Wang et al., 2019). In the context of MaaS, users pay for the effort to use the device so that they could get what they want (e.g., transport and travel information as well as transaction service) from the platform (Kamargianni et al., 2015; El-Haddadeh et al., 2019) and pay money to obtain the usage right of transportation through the mobility packages provided (MaaS Global, 2016).

We thus distinguish perceived values with respect to both platform and mobility service in the present study. Satisfaction refers to customers' overall effective evaluation based upon their experience obtained from their purchase or consumption of a product or service. It represents an emotional response or effect from the gap between prior expectation and perceived performance after consumption (Oliver, 1980) and has been widely identified as a critical determinant of favorable behavioral intention (Fu & Juan, 2017).

Satisfaction

Taking both platform and mobility service into account, our study measures satisfaction over a use experience of MaaS not only by overall satisfaction, but also satisfaction on the platform and mobility service. Behavioral intention represents an individual's expectation of a specific behavior in a given context, for which there is a possibility of action (Fishbein & Ajzen, 1975). The purpose of MaaS is to reduce the use of private cars and increase the use of public transport and shared resources to reach the target of sustainable transport (Sochor et al., 2015; Utriainen & Pollanen, 2018). This study measures behavioral intention by repurchase intentions and word-of-mouth, which reflect attitudinal loyalty toward MaaS.

Hypotheses

Relationships among service quality, perceived value, satisfaction, and behavioral intentions have been widely discussed in the service industries literature (Cronin et al., 2000) as well as public transport literature (De Ona et al., 2015; Fu & Juan, 2017; Lai & Chen, 2011; Su et al., 2021). Zeithaml (1988) proposes a value framework by which perceived value has a positive effect on purchase intention. Woodruff (1997) suggests that satisfaction reflects the overall feeling that customers get from perceived value. The Cognition-Affect-Conation model supports that customers' positive behavioral intention is derived from their satisfaction (Jen et al., 2011). In general, as suggested by the service quality-perceived value-satisfaction-behavioral intention framework (Cronin et al. 2000), value judgments are influenced by perceived service quality and influence satisfaction, behavioral intention, customer loyalty, and other important outcomes. Customer satisfaction positively impacts behavioral intention or target behavior. Based upon the aforementioned theoretical background and evidence from previous studies, we propose the following hypotheses in this study. Note that platform service quality consists of informativeness and transaction convenience while mobility service quality consists of economic benefit and mobility convenience, referring to Sect. 4.1.

H1: Platform service quality positively relates to perceived platform value.
H1a: Informativeness positively relates to perceived platform value.
H1b: Transaction convenience positively relates to perceived platform value.
H2: Mobility service quality positively relates to perceived mobility value.
H2a: Economic benefit positively relates to perceived mobility value.
H2b: Mobility convenience positively relates to perceived mobility value.
H3: Perceived platform value positively relates to behavioral intentions.
H4: Perceived mobility value positively relates to behavioral intentions.
H5: Perceived platform value positively relates to satisfaction.
H6: Perceived mobility value positively relates to satisfaction.
H7: Satisfaction positively relates to behavioral intentions.

Method

Participants and procedure

We collect data from users of a Taiwanese MasS named MeNGo, which was launched in September 2018. In collaboration with the MeN Go marketing team, we posted an online survey information on several channels including MeN Go App, MeNGo official website, and associated social media (i.e., Facebook and LINE). The online survey was conducted in February 2020 and obtained 468 responses in total. After excluding invalid or uncompleted ones, we use 435 valid samples for subsequent data analyses.

Table 1 presents the profile of the respondents. The majority of the respondents are female, accounting for 61.6% of the sample, and respondents evenly range between 16 and 50 years of age. Among the respondents, the majority are students (30.1%) and respondents with a working status (61.6%), while 76.7% of respondents hold at least a bachelor degree. Regarding weekly use frequency of MeNGO, using the app less than 5 times is the major-

Table 1 Sample profile

Characteristic		Frequency	Percentage
Gender	Male	38.4	38.4%
	Female	268	61.6%
Age (Years)	16 ~ 20	97	22.3%
	21 ~ 30	91	20.9%
	31 ~ 40	125	28.7%
	41 ~ 50	93	21.4%
	Above 51	29	6.6%
Occupational status	Student	131	30.1%
	Working	268	61.6%
	Not working	36	8.3%
Education	Senior high school or below	101	23.2%
	Bachelor degree	242	55.6%
	Master's degree or above	92	21.1%
Monthly income (TW$)	Below 10,000	146	33.6%
	10,001 ~ 20,000	50	11.5%
	20,001 ~ 30,000	79	18.2%
	30,001 ~ 40,000	66	15.2%
	40,001 ~ 50,000	40	9.2%
	Above 50,001	54	12.4%
Use frequency of MeNGo app	None	57	13.1%
	1 ~ 5 times a week	274	63.0%
	6 ~ 10 times a week	55	12.6%
	11 ~ 20 times a week	32	7.4%
	Above 20 times a week	17	3.9%
Use frequency of MeNGo mobility service	Below 6 times a week	105	24.1%
	7 ~ 10 times a week	170	39.1%
	11 ~ 20 times a week	102	23.4%
	Above 21 times a week	58	13.3%
Use experience of MeNGo	Less than 3 months	115	24.6%
	3 ~ 6 months	71	15.2%
	6 ~ 9 moths	59	12.6%
	9 ~ 12 moths	36	7.7%
	Over 12 months	187	40.0%

ity (76.1%), while respondents using MaaS mobility service between 7 and 10 times and those between 11 and 20 times account for 39.1% and 23.4%, respectively. Around 40% of respondents have MeN Go usage experience of over one year, and those with experience between 6 and 12 months account for 20.3%.

Measures

The measurement items of all constructs except satisfaction in the questionnaire are adapted from the existing literature with proper modification to fit the MaaS context. The perception of service attributes is conceptualized by both platform service attributes and mobility service attributes. Platform service attributes are measured by two dimensions: informativeness (INF) −3 items from Huang et al. (2017); and transaction convenience (TC) −4 items from Duarte et al. (2018). Mobility service features are measured by four dimensions: economic benefit (EB) – 3 items from Meyer-Waarden (2013); seamlessness (SE) – 3 items from Cheng & Chen (2015); perceived accessibility (AC) – 4 items from Lattman et al. (2016); and flexibility (FL) – 3 items from Han et al. (2018). Perceived value is measured by both perceived platform value (PPV) and perceived mobility value (MPV). PPV is measured by 3 items from El-Haddadeh et al. (2019), and MPV is measured by 3 items form Jen et al. (2011). Satisfaction is measured by 3 items according to the service characteristics of MaaS of MenGo. Behavioral intention (BI) is measured by 3 items from Duarte et al. (2018). A five-point Likert scale (from 1 = "Strongly disagree" to 5 = "Strongly agree") is used to measure all items. Measurement items are in Appendix 1.

Data analysis

This study performs statistical analyses using statistics software of SPSS 22.0 and Amos 24.0. Descriptive statistics analysis can help us analyze the demographic profile of MaaS subscribers. Exploratory factor analysis identifies the underlying dimensions of the platform and mobility service features of MaaS. To examine the proposed conceptual model, we follow Anderson & Gerbing's (1988) two-step approach for structural equation modelling (SEM) with the maximum likelihood method. We first employ confirmatory factor analysis to examine the measurement model for its convergent validity, discriminant validity, and goodness-of-fit, followed by estimating the structural equation model to test the hypotheses of the conceptual model. Indices including normed chi-square ($\chi 2$ /d.f.), normed fit index (NFI), comparative fit index (CFI), root mean square of approximation (RMSEA), and root mean square residual (RMR) are used to assess the model fitness. According to Hair et al. (2010), a model with fit values of RMSEA and RMR less than 0.08 and both NFI and CFI higher than 0.9 is deemed as acceptable.

Results

Dimensionality of MaaS service quality

This study utilizes the existing scales from various related studies to measure MaaS service quality with respect to the service features of both platform and mobility. We then apply exploratory factor analysis with principal component analysis (PCA) and the varimax rotation method to examine the underlying dimensions of platform and mobility service features in the MaaS context. The study subsequently employs the underlying dimensions to specify the measurement model.

The EFA results for the seven items of platform service quality (as seen in Table 2) show two distinct factors with eigenvalue greater than 1 and with 77.32% of variance explained. Checking the items of each factor, the factorial structure strongly fits into the two dimensions of informativeness (Cronbach $\alpha = 0.88$) and transaction convenience (Cronbach $\alpha = 0.89$), which the original scales adapted. Following the same estimation procedure, the EFA results of the thirteen items of mobility service quality (as shown in Table 3) present only two factors with eigenvalue greater than 1 and with 66.63% of variance explained. The items of perceived accessibility, seamlessness, and flexibility are delineated as one factor,

Table 2 Result of EFA for platform service features

Dimension	Factor loading	Communalities	Eigenvalues	Pct. of variance
Informativeness (INF)			2.44	34.91%
INF1. MeNGo app provides useful information	0.83	0.75		
INF2. MeNGo app help me evaluate my travel.	0.89	0.83		
INF3. MeNGo app enables me complete my travel with detailed information provided.	0.83	0.83		
Transaction convenience (TC)			3.00	42.41%
TC1. MeNGo app has a flexible payment method for transport ticket.	0.78	0.66		
TC.2 MeNGo app's check-out process for transport ticket is fast.	0.84	0.77		
TC3. Using MeNGo app to purchase transport ticket is easy.	0.86	0.81		
TC4. MeNGo app's purchase process for transport ticket is quick.	0.88	0.76		

which is labelled as mobility convenience (Cronbach α = 0.93) based upon the content of items. The items of economic benefit remain within the same factor and are hence labelled as economic benefit (Cronbach α = 0.89). To sum up, we specify the platform service quality of MaaS with the two dimensions of informativeness and transaction convenience, while the mobility service quality of MaaS has two dimensions of economic benefit and mobility convenience in the following measurement model.

Table 3 Result of EFA for mobility service antecedents

Dimension	Factor loading	Communalities	Eigen-values	Pct. of variance
Mobility convenience (MC)			5.41	41.65%
MC1. Using MeNGo's mobility service helps me reduce the transfer time.	0.67	0.59		
MC2. Using MeNGo's mobility service for transfer is easy.	0.70	0.64		
MC3. The transport modes integrated by MeNGo mobility service meet my needs.	0.61	0.60		
MC4. It is easy to do daily activities with MeNGo mobility service.	0.69	0.67		
MC5. If MeNGo mobility service is my only mode of travel, I would be able to continue living the way I want.	0.63	0.46		
MC6. It is possible to do my preferred activities with MeNGo mobility service.	0.76	0.64		
MC7. Access to my preferred activities is satisfactory with MeNGo mobility service.	0.78	0.70		
MC8. The waiting time for the transport modes provided by MeNGo mobility service is not long.	0.82	0.68		
MC9. The transport modes provided by MeNGo mobility service are rarely delayed.	0.75	0.57		
MC10. Using MeNGo mobility service to complete my journey is convenient.	0.82	0.71		
Economic benefit (EB)			3.24	24.98%
EB1. MeNGo mobility service scheme is the best way to reduce the travel cost.	0.80	0.71		
EB2. MeNGo mobility service scheme gives monetary advantages.	0.89	0.84		
EB3. MeNGo mobility service scheme allows to make substantial economic benefit.	0.90	0.86		

Measurement model

Before estimating the models, we examine the presence of common method variance to rule out the biasing effect (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) since the data of all constructs are collected from the same respondents. The results from Harman's single-factor test reveal that a single factor account for 44.8%, or less than 50% of the total variance (Podsakoff et al., 2003), indicating common method bias does not appear to be a significant problem.

We conduct CFA to examine the convergent validity of the measurement model, which is assessed by item reliability, construct reliability (CR), and average variance extracted (AVE) (Hair et al., 2010). Table 4 reports the estimated CFA results after removing two items (AC3 and FL2), because their standardized factor loadings are less than 0.7, which is the cut-off value recommended by Hair et al. (2010). The model fit indices of the measurement model, including $\chi2/df=2.03$, NFI = 0.91, CFI = 0.95, RMSEA = 0.05, and RMR = 0.03, meet the cut-off values recommended by Hair et al. (2010) and indicate the measurement model has an acceptable fit to the data.

As shown in Table 4, all standardized factor loadings of each construct are greater than 0.7, and the AVE values of all constructs are well above the suggested value of 0.5. All CR values are greater than 0.7, reaching acceptable reliability (Nunnally, 1978). Hence, convergent validity of the measurement model is confirmed (Fornell & Larcker 1981). To examine discriminant validity, we further compare the squared root value of AVE for each construct with the correlation between the construct and other constructs. As shown in Table 5, all square roots of AVE are greater than the correlation coefficient between two constructs (see Table 5), supporting the measures' discriminant validity (Fornell and Larcker, 1981).

Structural model

Fig. 2 shows the results of the structural model with estimates. The fit indices of the structural model support a good fit to the data [χ 2/d.f.= 2.47, NFI=0.91, CFI=0.94, RMSEA=0.06, RMR=0.04]. We assess the hypothesis tests by a one-tail test based upon their associated hypothetical directions. Seven out of nine hypotheses in our model are supported.

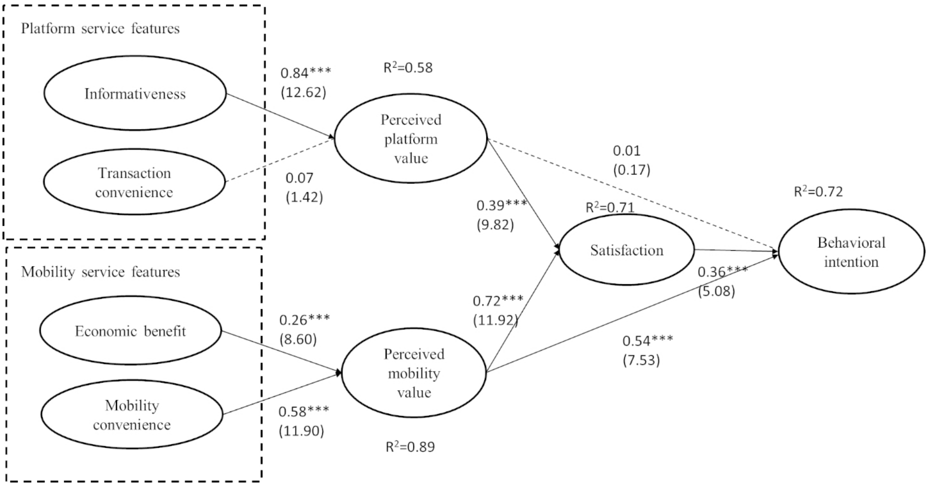

Fig. 2 Structural model, Note ***p<0.001; **p<0.01; *p<0.05

Regarding the effects of platform service quality, informativeness is found to have a significantly positive effect on the perceived value of platform, supporting H1a (β=0.84, t=12.62), while the effect of transaction convenience is not significant and does not support H1b (β=0.07, t=1.42). With respect to the effects of mobility service quality, both economic benefit (β=0.26, t=8.60) and mobility convenience (β=0.58, t=11.90) are found to have significantly positive effects on perceived value of mobility, supporting H2a and H2b, respectively. Both perceived platform value (β=0.39, t=9.82) and perceived mobility value (β=0.72, t=11.92) appear to have significantly positive effects on satisfaction, hence supporting H3 and H4.

The influential effects on behavioral intention, perceived mobility value (β=0.54, t=7.53), and satisfaction (β=0.36, t=5.08) indicate support for H6 and H7, respectively, while H5 is not supported, because of the insignificantly positive effect of the perceived platform value (β=0.01, t=0.19). Table 6 summarizes the hypothesis tests' results.

Table 4 Reliability and convergent validity

Construct/ Indicators	Item reliability			CR	AVE
	Standard factor loading	**Standard error**	**T-value**		
Informativeness (INF)					
INF1. MeNGo app provides useful information.	0.79	0.38	-	0.88	0.71
INF2. MeNGo app helps me evaluate my travel.	0.87	0.25	19.35**		
INF3. MeNGo app enables me complete my travel with detailed information provided.	0.87	0.28	19.39**		
Transaction convenience (TC)					
TC1. MeNGo app has a flexible payment method for transport ticket.	0.81	0.35	12.35**	0.89	0.66
TC2. MeNGo app's check-out process for transport ticket is fast.	0.87	0.24	14.51**		
TC3. Using MeNGo app to purchase transport ticket is easy.	0.81	0.34	-		
TC4. MeNGo app's purchase process for transport ticket is quick.	0.76	0.43	15.18**		
Economic benefit (EB)					
EB1. Using MeNGo's mobility service helps me reduce the transfer time.	0.75	0.43	19.96**	0.90	0.75
EB2. Using MeNGo's mobility service for transfer is easy.	0.91	0.17	28.12**		
EB3. The transport modes integrated by MeNGo mobility service meet my need.	0.91	0.17	-		
Mobility convenience (MC)					
MC1 Using MeNGo's mobility service helps me reduce the transfer time.	0.72	0.48	17.94**	0.92	0.59
MC2. Using MeNGo's mobility service for transfer is easy.	0.76	0.42	-		
MC3. The transport modes integrated by MeNGo mobility service meet my needs.	0.71	0.49	16.96**		
MC4. It is easy to do daily activities with MeNGo mobility service.	0.78	0.39	18.08**		
MC6. It is possible to do my preferred activities with MeNGo mobility service	0.77	0.40	16.57**		
MC7. Access to my preferred activities is satisfactory with MeNGo mobility service.	0.84	0.30	18.11**		
MC8. The waiting time for the transport modes provided by MeNGo mobility service is not long.	0.73	0.47	15.57**		
MC10. Using MeNGo mobility service to complete my journey is convenient.	0.79	0.37	17.16**		
Perceived platform value (PPV)					
PPV1. Compared to the effort I need to put in, the usage of MeNGo website and app is beneficial to me.	0.84	0.30	-	0.89	0.72
PPV 2. Compared to the time I need to spend, the usage of MeNGo website and app is worthwhile to me.	0.92	0.16	23.45**		
PPV 3. Overall, the usage of MeNGo website and app provides good value for me.	0.79	0.37	19.42**		
Perceived mobility value (PMV)					
PMV1. MeNGo mobility service offered is valuable.	0.75	0.43	-	0.80	0.57

Table 4 (continued)

Construct/ Indicators	Item reliability			CR	AVE
	Standard factor loading	**Standard error**	**T-value**		
PMV2. MeNGo mobility service based on a certain price is acceptable.	0.72	0.48	14.96**		
PMV3. It is worthwhile to travel by MeNGo mobility service than by other companies.	0.78	0.39	16.34**		
Satisfaction (SAT)					
SAT1. I am satisfied with the function provided by MeNGo's application and website.	0.82	0.34	-	0.88	0.71
SAT2. I am satisfied with the mobility service provided by MeNGo.	0.86	0.27	20.81**		
SAT 3. I am satisfied with the overall services provided by MeNGo.	0.86	0.25	21.08**		
Behavioral intention (BI)					
BI1. I am willing to continue using MeNGo service.	0.87	0.24	-	0.90	0.75
BI2. I am willing to recommend others to use MeNGo service	0.85	0.28	23.06**		
BI3. I will use MeNGo service more often	0.87	0.24	24.21**		

Note: MC5 and MC9 are removed from CFA due to low factor loadings

Table 5 Results of discriminant validity

Construct	Mean	SD	INF	TC	EB	MC	PPV	PMV	SAT	BI
INF	3.71	0.71	**0.84**							
TC	4.11	0.67	0.44	**0.81**						
EB	4.11	0.75	0.25	0.35	**0.86**					
MC	3.93	0.62	0.46	0.37	0.59	**0.77**				
PPV	3.70	0.71	0.66	0.37	0.32	0.48	**0.85**			
PMV	3.92	0.67	0.37	0.35	0.67	0.73	0.42	**0.75**		
SAT	3.93	0.66	0.58	0.52	0.48	0.68	0.62	0.62	**0.85**	
BI	4.19	0.65	0.42	0.47	0.60	0.66	0.49	0.66	0.70	**0.87**

Note: The diagonal of the matrix is the root of AVE

Table 6 Results of hypotheses' testing of the structural model

Hypothesis	Estimate	T-value	Testing result
H1a: INF -->PPV	0.84	12.62	Supported
H1b: TC --> PPV	0.07	1.42	Rejected
H2a: EB --> PMV	0.26	8.60	Supported
H2b: MC --> PMV	0.58	11.90	Supported
H3: PPV-->BI	0.01	0.17	Rejected
H4: PMV-->BI	0.54	7.53	Supported
H5: PPV --> SAT	0.39	9.82	Supported
H6: PMV --> SAT	0.72	11.92	Supported
H7: SAT --> BI	0.36	5.08	Supported

To understand whether satisfaction plays a mediator between both perceived values and

Table 7 Total effect of perceived value and satisfaction on behavioral intention

Path	Direct effect	Indirect effect (Mediator SAT)	Total effect (Direct effect + Indirect effect)
PPV → SAT	0.39**	-	0.34**
MPV → SAT	0.72**	-	0.72**
PPV → BI	0.01	0.14***	0.15**
MPV → BI	0.54**	0.26***	0.80**
SAT → BI	0.36**	-	0.36**

Note: *** p-value < 0.001; ** p-value < 0.01; and * p-value < 0.05 by the bootstrapping test.

behavioral intention, we calculate the direct effects, indirect effects, and total effects among perceived value, satisfaction, and behavioral intention and test the mediation effect of satisfaction by applying bootstrapping 2000 times (Preacher & Hayes, 2008). The result (see Table 7) shows that the total effect of perceived mobility value (0.8) is much larger than that of perceived platform value (0.15), and that satisfaction has a significant mediating effect between perceived value and behavioral intention. More specifically, the mediating effects with respect to platform and mobility are full and partial, respectively.

Discussion and conclusions

Different from most existing studies in the literature, this study identifies and explores the service features of MaaS and investigates the interrelationships among users' perceived service quality, perceived value, satisfaction, and behavior intention in the context of a real-world MaaS system. To reflect the comprehensive characteristics of the MaaS design, we specifically consider two main components of MaaS, platform and mobility, together in order to specify the service features and perceived value in our study. Through exploratory factor analysis our results identify service features for the MaaS platform in two dimensions (interactivity and informativeness) and for MaaS mobility in two dimensions (economic benefit and mobility convenience). Furthermore, different from the perceived valued measured in general aspects such as functional, hedonic, and social values in related literature (Wang et al., 2019), we calculate the perceived value with respect to both platform and mobility so as to take a deeper look into their effects on users' satisfaction and in turn behavioral intention. Using survey data collected from an existing MaaS application called MeN Go operating in Kaohsiung, Taiwan, our results in general confirm the service quality-perceived value-satisfaction-behavioral intention framework, but two of the hypotheses are not supported.

Discussion

While both informativeness and transaction convenience are identified as two platform service attributes, only perceived quality of informativeness is found to have a significantly positive effect on perceived platform value, which is consistent with previous studies (Huang et al., 2017; Jeong & Shin, 2020). As emphasized in previous MaaS studies (Ho et al., 2018; Kamargianni & Matyas, 2017; Mulley et al., 2018), platform serves as the key channel between customers and mobility service providers. The functionality and quality of platform that provides easy access to open data such as timetables of transport, real-time transport information, and integrated information are prerequisites for the success of MaaS schemes. With the support of platform functions, users can get accurate transfer information and the recommended best route, so that they can then perceive the value from the platform's informativeness in terms of reducing both travel time uncertainty and scheduling costs (Ettema & Timmermans, 2006; Tan & Chen, 2012).

The MaaS platform also serves as the mobile commerce channel between customers and mobility service providers for purchases of the mobility service through the mobile payment platform. While a convenient transaction or payment mechanism within a MaaS platform is a big concern as noted in previous studies (Kamargianni et al., 2015; Chang & Polonsky, 2012; Ngoc Thuy, 2011) and cannot be neglected, the effect of transaction convenience on perceived platform value is not, however, significant in our findings as was expected. One possible reason might be because the current offerings by MenGo are prepaid monthly packages only. So far, users cannot pay via apps to purchase the trip schedule selected and plan it by themselves every time (i.e., pay-as-you-go) and then use the mobile payment for the monthly packages. According to previous research evidence, transaction convenience plays a crucial role in forming users' perceived value of an app's use. While our finding does not demonstrate the effect of transaction convenience offered by the app given the current prepaid scheme of MeNGo registration, it is believed and deserves future investigation that this specific platform service attribute will be likely to become more evident once a wide range of mobility services is available.

Regarding service quality of mobility service features, both mobility convenience ($\beta=0.58$) and economic benefit ($\beta=0.27$) positively influence perceived mobility value, which is consistent with previous public transport studies. Han et al. (2018) claim that convenience and economy are two important factors for people to use public transport. Kang et al. (2019) regard that the convenience of public transport influences people's intention to switch to public transport. MaaS thus provides integrated mobility service with better accessibility, seamlessness, and flexibility and therefore enhances users' mobility convenience and travel quality (Utriainen & Pollanen, 2018; Sochor et al., 2016). The discounted MaaS packages reduces users' travel costs and makes them feel cost-effective (Sochor et al., 2016). We find that the effect of mobility convenience is by and large two times that of economic benefit. Since the current cost of public transport such as bus, metro, and light rail in Kaohsiung is relatively inexpensive, it is understandable that users place more value perception on mobility convenience than price value. The finding also highlights the importance of mobility convenience, which offers better accessibility, seamlessness, and flexibility through the MaaS operator.

Regarding the interrelationships among perceived value, satisfaction, and behavioral intention, our findings are in general consistent with previous public transport studies (e.g., Jen et al., 2011; Lee, Yoon, & Lee, 2007; Ryu, Han & Kim, 2008). Overall, perceived value positively influences satisfaction and behavioral intention, and satisfaction has a positive influence on behavior intention. Our findings also show that both perceived platform value and perceived mobility value have significantly positive effects on customer satisfaction, which further leads to positive behavioral intention ($\beta=0.36$). Moreover, the effect of perceived mobility value ($\beta=0.72$) on satisfaction is much greater than that of perceived platform value ($\beta=0.39$), suggesting that the value created from better mobility service quality compared to a good platform mechanism results in users' overall satisfaction in MaaS. In particular, our findings show that perceived mobility value instead of perceived platform value has a direct positive effect on behavioral intention (i.e., reuse intention and WOM) apart from the direct effect of satisfaction on behavior intention. Taking perceived value and satisfaction together, the perceived mobility value has a much stronger effect (total effect: 0.8) on users' behavior intention compared to its effect on the platform (i.e., 0.15), indicating the core role of mobility service quality in sustaining MaaS operations given a well-functioning platform that interacts with users. In addition, the mediating role of satisfaction between perceived value and behavioral intention should be noted.

Implications

In general, the results indicate that the most strong variable explaining intention to use MaaS is mobility benefits derived from using MaaS, which is more than other variables such as cost/economic benefits, access to greater information, and ease of transaction. Hence, MaaS operators need to prioritize service features that offer access to newer modes, more frequent services, covering greater network areas. While other measures such as discounted pricing (targeting cost/economic benefits), provision of dynamic and real-time information (targeting informational benefits), integrated ticketing and payment (targeting transactional benefits), etc. are valuable, they are unlikely to prove popular with consumers unless the MaaS service can offer a substantial benefit in terms of access to new and expanded transport services. In particular, our study addresses that most current MaaS systems which have focused on integration within existing modes and services, to look beyond and endeavor finding ways to offer new services, if they are to build a consumer base.

First, to our best knowledge, this study is the first to propose an integrated model to investigate how MaaS quality influences users' perceived value and how perceived value influences users' satisfaction and behavioral intention. Going beyond previous MaaS studies on adoption intention, this study advances our understandings on MaaS users' satisfaction and behavioral intention and their affecting factors based upon actual use experience.

Second, by distinguishing the roles of platform and mobility service, two major components of MaaS service, this study identifies their respective service attributes and effects on perceived value and further presents how both components lead to user satisfaction and behavioral intention. From a service product perspective, users' willingness to continuously use or recommend to others depends upon a valuable and satisfactory MaaS experience. Nonetheless, mobility service should not be outweighed when addressing the importance of functions and design of a MaaS platform. The core product is mobility service through the integration of MaaS operations among various transport service providers when a MaaS platform serves the technology-facilitating role to enhance service convenience (information searching and transaction) for users.

Third, the significant effect of informativeness on perceived value indicates that the MaaS platform should endeavor to enhance its functionality and quality to provide accurate and useful information that users expect. Since personalization is one service feature frequently addressed in context platform and apps, the MaaS platform with its better personalization function should result in users' value perception. For example, the function to remember a user's travel habit and to provide appropriate travel suggestions based on the habit or preference is an example of personalization by the MaaS platform (Polydoropoulou et al., 2020).

Fourth, as mobility convenience appears to be the main factor leading to perceived mobility value and in turn satisfaction, the MaaS operator should endeavor to improve the extent of increased seamlessness, perceived accessibility, and flexibility of mobility service. Therefore, expanding operation coverage (Polydoropoulou et al., 2020) or integrating more transport modes (Sochor et al., 2015; Jittrapirom et al., 2020) are potential directions to consider for providing better mobility convenience.

Finally, economic benefit is also a significant service feature resulting in users' value perception. Thus, a MaaS operator should negotiate lower prices with mobility service providers to offer users an attractive discount for purchasing unlimited-use packages, other forms of products such as pay-as-you-go, or packages with flexible options (Kamargianni, et al., 2015; Lyons, et al., 2019).

Limitations and future research

There are several limitations of the present study that can be further investigated in future research. First, the behavioral intention used herein is measured by willingness to continuously use and willingness to recommend to others, representing attitudinal loyalty instead as the dependent variable in the conceptual model. While behavioral intention is commonly assumed to translate into actual behavior in theory, a gap between intention and actual behavior frequently exists in empirical evidence (Sheeran & Webb, 2016; Utriainen & Pollanen, 2018. It implies that people may not execute a behavior even if they express their intention. To obtain actual influences of service quality, perceived value, and satisfaction on actual behavior, future research can collaborate with MaaS companies to utilize users' actual behavioral data such as use frequency and purchase records apart from data collected on users' behavioral intention.

Second, this study mainly focuses on the influences of MaaS service attributes on users' perceived value, satisfaction, and behavioral intentions, without any concern for psychological factors. According to Schikofsky et al. (2020), individuals' psychological factors are also significant factors affecting MaaS use intention. Thus, future research can draw on motivation theory such as the self-determination theory (Deci & Ryan, 1985) and examine the effects of MaaS users' intrinsic motivation (e.g., autonomy and competence) and extrinsic motivation (e.g., perceived usefulness and perceived ease of use) on their behavioral intention and/or actual behavior.

Third, our findings merely result from a sample of Taiwanese MaaS (i.e., MeNGO) users. While MeNGo is one of the first operating MaaS schemes in Asia that is successful, the topic inevitably deserves more empirical evidence from other MaaS schemes in other regions or countries to generalize our model and findings.

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