Digital Transportation and Safety

ARTICLE

Open Access

https://doi.org/10.48130/dts-0024-0006

Digital Transportation and Safety **2024**, in press

Will the perceptions to incentive policies have any effect on users' willingness to participate in Mobility-as-a-Service?

Rongxuan Zhang[1], Lianqun Ouyang[2] and Lingling Xiao[1*]

[1] *School of Economics and Management, Beijing Jiaotong University, Beijing 100044, PR China*
[2] *College of E-Commerce, Tangshan University, Tangshan 063002, PR China*
* Corresponding author, E-mail: lxiao@bjtu.edu.cn

Abstract

With the increasing severity of urban traffic congestion and environmental pollution issues, Mobility-as-a-Service (MaaS) has garnered increasing attention as an emerging mode of transportation.Thus, how to motivate users to participate in MaaS has become an important research issue. This study firstly classified the incentive policies into four aspects: financial incentive policy, non-financial incentive policy, information policy and convenience policy. Then, through online questionnaires and the field interview, 456 relevant data were collected in Beijing, and the data were analyzed by structural equation model and latent class model. The results show that the four incentive policies are positively correlated with users' participation in MaaS, among which financial incentive policy and information policy have the greatest impact, that is, they can better encourage users by increasing direct financial subsidies and broadening the information about MaaS. In addition, we did Latent Class Analysis to class different users and we found that personal characteristics of users had some influence on willingness to participate in MaaS. Therefore, incentive policies should be designed to consider the needs and characteristics of different user groups to improve their willingness to participate in MaaS. The results can provide theoretical suggestions for the government to promote the widespread application of MaaS in urban transportation.

Keywords: Mobility-as-a-Service; Incentive policies; Personal traits; Latent class analysis

Citation: Zhang R, Ouyang L, Xiao L. 2024. Will the perceptions to incentive policies have any effect on users' willingness to participate in Mobility-as-a-Service? *Digital Transportation and Safety* https://doi.org/10.48130/dts-0024-0006

Introduction

With the development of the economy, people's demand for high-quality living is constantly increasing.In terms of transportation, there is a growing dependence on private cars, leading to an annual increase in car ownership. As a result, congestion and environmental pollution problems are becoming increasingly prominent, becoming a contradiction in urban transportation development. Although various shared modes of transportation have been widely mentioned, their effects have been minimal[1]. To alleviate related issues, Mobility as a Service has emerged and has become a new development in urban transportation in recent years. This service integrates public transportation with various shared modes of transportation, providing one-stop travel information services. The emergence of MaaS not only reduces the frequency of private car usage for travelers, but also reduces congestion, improves traffic efficiency, and thus protects the environment[2]. Internationally, Western countries have proposed new goals for MaaS in terms of integrating and green transportation, based on intelligent and digital transportation. At the same time, many provinces and cities in China actively utilize the development ideas of MaaS to solve urban transportation problems, taking into account their own urban transportation development status. In 2022, Beijing held a MaaS Ecosystem Development Forum to discuss the "Beijing MaaS 2.0 Work Plan", which plans to include new modes of transportation such as "rail+" in the Beijing MaaS plan; Shanghai aims to comprehensively promote MaaS and achieve "one code access" for rail transit, ground buses, and ferries. However, due to imperfect governance mechanisms and low levels of travel privacy and security[3], the participation of MaaS still needs to be improved. Therefore, it is still a research focus for scholars to call for more travelers to participate in MaaS travel in a targeted manner.

Carbon-inclusivity refers to the specific quantification of energy-saving and carbon reduction behaviors of small and micro-enterprises, community households, and individuals. It assigns a certain value to these efforts and establishes a positive guiding mechanism that combines commercial incentives, policy encouragement, and verified emission reduction trading.In the context of MaaS, transportation service apps like Ubigo and Whim in various countries have designed goals for low-carbon travel. In 2019, Beijing collaborated with Amap, launching the first domestic integrated green travel service platform. It implemented carbon incentives such as taxi fare refunds adn discounted vouchers to encourage travelers in choosing green travel options. Furthermore,in terms of travel incentives, scholars have expressed diverse opinions on the effectiveness of different measures. Researchers believe that the incentive approach is related to the individual characteristics of travelers[4] and their socio-economic attributes[5].Different incentive measures can alleviate peak travel demand from different perspectives.For example, financial incentives not only encourage people's participation in non-motorized travel

but also have long-term effects on travelers' travel behavior[6,7]. Information incentives can promote sustainable low-carbon consumption among individuals[8] and so on.

In order to promote the participation of travelers in MaaS, previous studies have mainly explored the preferences and willingness of travelers to use MaaS, as well as the factors behind these preferences. Several literature suggests that, User participation in MaaS travel and their travel habits[9], Environmental awareness and the awareness of innovation[10]and other personal characteristics have significant relationships, besides, In recent years, some scholars have combined the satisfaction of MaaS participation with gender, age, and occupation[11] and other combination of personal characteristics; Some scholars have also conducted research from the perspective of a specific population, For example, Veer[12] analyzed the acceptance attitude of the commuter population towards MaaS, and Kriswardhana[13] explored the preference of college students for MaaS. With the development of intelligent transportation, the related research on MaaS at home and abroad is gradually increasing. However, most of the existing studies only focus on the acceptance of MaaS by different populations, and lack the discussion of how to motivate more different groups of users to participate in MaaS. Therefore, this paper comprehensively considers the following three directions: First, Explore the willingness of users with different characteristics to participate in MaaS under the incentive policies; next, According to the existing literature, The personal characteristics of users were included in the study of behavioral intention; last, As MaaS services are just emerging in China, To explore the intention of different populations to participate in MaaS[14], The potential category analysis of the above influencing factors, To study the willingness of populations with different social attributes and travel characteristics to participate in MaaS, It provides a targeted reference basis for the application and promotion of MaaS travel in China.

Literature review

Research on the incentive policies

While MaaS is considered a new direction for future urban transportation, whether it can undermine the dominance of private car travel largely depends on the level of participation by travelers[15]. Therefore, governments and operators have to formulate related policies to promote travelers' participation in MaaS from different angles[16,17]. Relevant research has also confirmed the positive effects of financial and non-financial incentives on travel behavior. For example, direct price subsidies and exemption from purchase taxes can incentivize travelers to use electric vehicles[18]; financial incentives are more effective in encouraging travelers to accept smart mobility services compared to other approaches[19]. Additionally, the Chinese Amap platform has incorporated both financial and non-financial incentives into Beijing MaaS platform design. It assigns corresponding carbon energy values based on individuals' level of participation in MaaS, providing incentives such as discounted ride vouchers and discounts from relevant third-party partner businesses to encourage traveler participation[20]. Besides, according to the discussion on the integration level[21], information integration functionality is the first-level requirement of an integrated platform. As a mobility integration service platform, MaaS also provides travelers with one-stop travel information services, offering convenient services. In existing services, platforms like Whim in Finland, Ubigo in Sweden have all incorporated real-time travel information into their MaaS services[22]. They provide travelers with information such as intelligent trip planning, travel times, and distances[23], thereby saving travelers' time spent waiting for transportation and queuing. Additionally, to encourage low-carbon travel, some platforms also provide real-time information on carbon emissions and combine it with carbon-inclusive incentives.At the same time, to improve the design of MaaS platform and encourage more travelers to choose non-private car travel modes, various local governments have issued different policies to enhance travel convenience. According to the annual report released by "Suishenxing" (Shanghai MaaS service platform) in 2022, Shanghai's government-developed MaaS platform integrates various travel modes and services, including ferries, ride-hailing, shared bicycles, maglev trains, and smart parking[24]. Furthermore, the inclusion of electric shared scooters and carpooling into the MaaS platform provides travelers with more options[25].

Research on the personal traits

Many scholars believe that the heterogeneity of travelers has a significant impact on their participation in MaaS. Therefore, scholars have expanded models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) to understand the heterogeneity of users' participation in MaaS based on different habits and personality traits[26,27]. Hence, this study refers to existing literature on the impact of individual traits on MaaS participation and discusses the influencing factors in four aspects: Innovation trait, Habit schema congruence, Environment trait, and Social influence.

Innovation trait is considered one of the influencing factors for individuals' willingness to accept new products and technologies[28]. As a integrated platform, MaaS not only innovates users' travel methods but also introduces a brand-new "one-stop" platform technology into the urban transportation system. Compared to traditional travel methods, MaaS can provide not only point-to-point travel recommendations but also various travel modes' supplementary information[29]. Technophilia[30] refers to a group of people who have a preference for new technologies or products. These individuals often exhibit more enthusiasm for engaging with new technologies[31,32]. They are also an important target audience for promoting MaaS, as they tend to have a positive impact on the usage intention and participation level of MaaS[33].Since MaaS requires people's participation through mobile devices, travel habits not only include users' choice of transportation modes but also their usage habits of mobile devices. Under the concept of MaaS, which may disrupt traditional travel patterns, users with consistent travel habits are considered to be more receptive to MaaS services and they may have a higher willingness to pay for it[34]. According to existing literature, environmentalists are often more inclined towards public transportation travel[35]. As MaaS is considered to encourage low-carbon travel and maximized social welfare associated with travel impacts[36,37], individuals with high environmental awareness are more likely to prefer participating in MaaS. In addition to individual characteristics, social networks are often considered an important factor influencing people's behavior. Previous studies have also shown that social influence has a positive

impact on people's acceptance of automated public transport[38],driveless cars[39] and other new travel modes. Therefore, social influence factors are frequently included in adoption studies of new transportation technologies[40,41]. The results consistently show that social influence factors have a positive impact on user participation in new travel modes.

Research gap

Based on the literature reviewed above, it is evident that MaaS has also received a lot of attention in China. With the emphasis on intelligent transportation, related research on MaaS has gradually increased. However, a majority of the existing research is derived from foreign investigations and empirical studies on the acceptance of MaaS, while research on this topic in China remains limited. Furthermore, most of the studies only focus on the acceptance of MaaS by different populations, with a lack of relevant discussion on the related policies for MaaS. Therefore, this paper focuses on the incentives that affect travelers, and takes into account personal characteristics in combination with the theoretical basis of TAM and UTAUT models to identify policies that encourage or discourage consumer adoption of MaaS.

Materials and methods

Based on the above mentioned research gap, this paper proposes 9 hypotheses. The research framework is illustrated in Fig 1.

Conceptual model and proposed hypotheses

In this study, financial policies refer to the measures taken by the government or providers, which could encourage people's participation in MaaS by travel discounts or subsidies.

Non-financial policies, on the other hand, involve the carbon coin or carbon incentives through mechanisms such as total control and free quotas.

Information policy refers to "the degree to which users are prefer to the information offered by MaaS platform". People can obtain information about travel planning, estimated time and estimated cost from the platform. These comprehensive travel information shows the various possibilities of travel in front of users, which may encourage people to participate in MaaS.

Convenience policy can be defined as "Compared with traditional travel services, MaaS has a convenience policy". Since MaaS is a one-stop travel service platform, the platform will bring the technical convenience and policy convenience besides the travel service itself, which may also affect the participation degree of users.

H1. Financial incentive policy is positively related to the attitude to MaaS (H1a) and behavior to MaaS (H1b).

H2. Non Financial incentive policy is positively related to the attitude to MaaS (H2a) and behavior to MaaS (H2b).

H3. Information policy is positively related to the attitude to MaaS (H3a) and behavior to MaaS (H3b).

H4. Convenience policy is positively related to the attitude to MaaS (H4a) and behavior to MaaS (H4b).

Innovation trait refers to "the degree to which users are willing to actively try new travel modes". When users can actively face new technology products, it can be assumed that they will also be willing to explore MaaS in advance or try them out more actively.

Habit schema congruence can be defined as "The similarity of the user's current travel pattern to the MaaS". As a new transportation mode, MaaS need users to be familiar with mobile phones, such as navigation softwares. If users have a similar travel habit, their willingness to take part in MaaS will also increase.

Environment trait refers to users' environmental awareness, which includes their concerns about environmental pollution and their participation in environmental behaviors. MaaS as a representative of low-carbon travel, we guess that users with higher environmental awareness will be more willing to participate in it.

Social influence specifically is defined as "the degree to which users are influenced by the surrounding group when accepting MaaS", especially authoritative media, relatives and governments will have an impact on individual behavior. Thus, the following hypothesis is proposed:

H5. Innovation trait is positively related to the attitude to MaaS (H5a) and behavior to MaaS (H5b).

H6. Habit schema congruence is positively related to the atti-

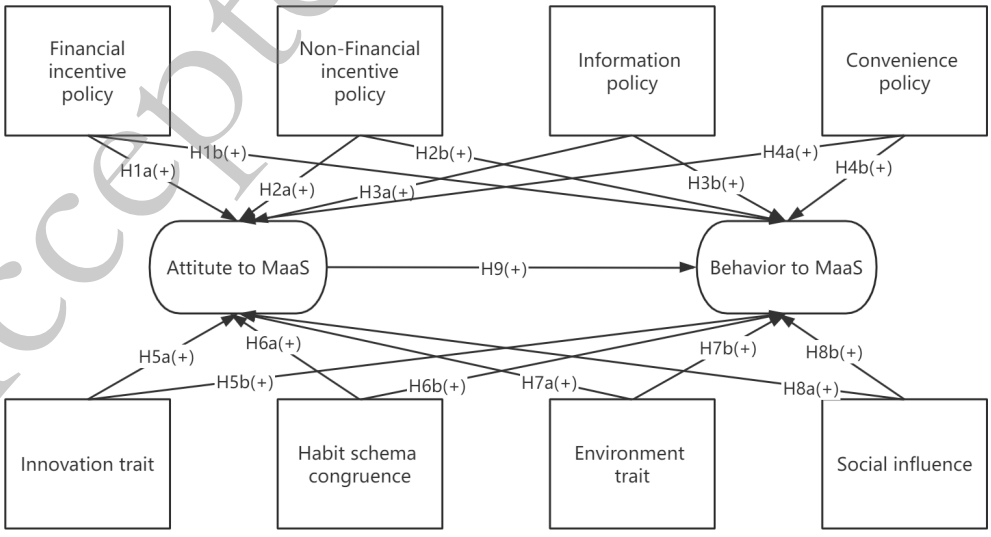

Fig. 1 Research framework.

tude to MaaS (H6a) and behavior to MaaS (H6b).

H7. Environment trait is positively related to the attitude to MaaS (H7a) and behavior to MaaS (H7b).

H8. Social influence is positively related to the attitude to MaaS (H8a) and behavior to MaaS (H8b).

Theory of Reasoned Action (TRA) believes that, to some extent, the individual's attitude and subjective criteria can affect one's behavioral intention, and the individual's behavioral intention can reasonably infer the final behavior. Therefore, based on the conclusions of previous scholars, this paper proposes hypothesis H9:

H9. Attitude to MaaS is positively related to the behavior to MaaS.

Survey design

This study employed a combined online and offline questionnaire survey to collect data. The questionnaires were distributed in Beijing, China. The main reason for selecting Beijing was that it launched China's first integrated green travel MaaS service platform in November 2019, making it the first demonstration city for promoting MaaS in China. So users in Beijing would have a better understanding of MaaS-related policies. Additionally, as one of China's mega-cities, Beijing has well-developed public transportation infrastructure, which provides a larger pool of potential MaaS users. To enhance the effectiveness and validity of the questionnaire, a pre-survey was conducted with 40 participants representing different demographic characteristics, and the questionnaire was modified and optimized accordingly.

The questionnaire in this study consisted of four parts. The first part was about MaaS travel acceptance and questionnaire screening, including "Have you heard of MaaS travel?" or "Have you participated in MaaS travel?" If the respondent answered "yes" to either of these questions, they were considered to have a certain understanding of MaaS. Otherwise, the questionnaire was considered invalid. The second part was about personal characteristics, including gender, age, monthly income, education level, and commuting characteristics.The third part focused on perceived information, aiming to understand the respondents' awareness of existing financial incentive policies (FIP), non-financial incentive policies (NFIP), information policies (IP), and convenience policies (CP) related to MaaS. The fourth part gathered information about the respondents' characteristics, exploring the heterogeneity under innovation traits (IT), habit schema congruence (HSC), environmental traits (ET), and social influence (SI). The respondents were asked to rate their level of agreement on a Likert scale ranging from "1=strongly disagree" to "5=strongly agree" in relation to all the measured items. Table 1 contains the complete scale. Additionally, to ensure data quality, deception questions were included in the questionnaire. Ultimately, 64 questionnaires that did not pass the screening were removed, resulting in a final sample of 456 respondents.

Results and discussion

Demographic analysis

Among the 456 questionnaires, the proportion of males and females was 50%. Respondents aged between 18 and 24

Constructs	Items	Item descriptions
Financial incentive policy	FIP1	For adopting MaaS, direct financial subsidy is attractive to me.
	FIP2	For adopting MaaS, subsidy for travel is very attractive to me.
	FIP3	For adopting MaaS, getting the discount coupon available to supermarket is very attractive to me.
Non-Financial incentive policy	NFIP1	For adopting MaaS, participating in charity donation (Ant Forest from Alibaba) is very attractive to me.
	NFIP2	For adopting MaaS, getting the carbon coin is very attractive to me.
Information policy	IP1	For adopting MaaS, the information about route planning is useful to me.
	IP2	For adopting MaaS, the information about predicted travel time and cost is helpful.
	IP3	For adopting MaaS, the Information related to the real-time free parking space is helpful to me.
	IP4	For adopting MaaS, the information related to my carbon footprint is valuable to me.
Convenience policy	CP1	For adopting MaaS, one-code pass (a QR code can scan all public transport services) is essential.
	CP2	For adopting MaaS, connect with other travel platform(such as taxi system)is essential.
	CP3	For adopting MaaS, reducing the queuing time makes sense for me.
Innovation trait	IT1	I am always curious about new things.
	IT2	I usually take the lead in trying new technologies compare to people aroud me.
	IT3	I think it's very interesting to try out the new travel service mode.
Habit schema congruence	HSC1	MaaS system is similar with my current way of travel.
	HSC2	MaaS system is similar to the product or service that I am used to.
	HSC3	I am familiar with using my smartphone for payments and I always take it with me outside.
	HSC4	I am familiar with the use of journey planning apps (for example Google Map)
Environment trait	ET1	I am very concerned about the environment, and I feel that environmental problems have become more and more serious.
	ET2	I think the harmony between man and nature can promote sustainable development.
	ET3	I think that everyone has the responsibility to protect the environment.
	ET4	I am worried about the future shortage of natural resources.
Social influence	SI1	I am willing to adopt MaaS if the government evaluation is good.
	SI2	I am willing to adopt MaaS if the media evaluation is good.
	SI3	I am willing to adopt it if MaaS can get support and praise from people around me.
Attitude to MaaS	ATM1	I think it is necessary to travel with MaaS.
	ATM2	I think the government should encourage the use of MaaS mode.
	ATM3	I think once I use the MaaS, I will reduce my car usage.
Behavior to MaaS	BTM1	I plan to be involved in the MaaS travel mode in the future.
	BTM2	I am looking forward to take part in the MaaS travel mode in the future.

accounted for 31.1% of the total sample, followed by those aged 25–34 (30.7%). 49.7% of the respondents had a bachelor's degree, and students represented 27.4% of the sample. The proportions of respondents who were employees in companies, government agencies, and institutions ranged from 16% to 19%. Additionally, over 50% of the respondents had a monthly income between 5,000 and 20,000(yuan), while the remaining 55% had a monthly income below 10,000 yuan.

Furthermore, it is worth noting that 76.9% of the respondents owned private cars, but the public transportation mode had the highest proportion in the sample (43.2%), followed by private car usage (30.0%). Table 2 provides an overview of the respondents' demographic characteristics.

Reliability and validity test of measurement model

The data were analyzed by AMOS 24. Confirmatory factor analysis (CFA) was conducted to assess the validity and reliability of the measurement model. Structural equation modeling (SEM) was used to test the hypotheses proposed in this study.

The results of the calculations are presented in Tables 3 and 4.

The overall fit of the model was evaluated using fit indices. All indices (χ^2/df = 1.779, CFI = 0.965, TLI = 0.958, RMSEA = 0.041) were within the recommended threshold ranges[42]. The reliability of the scales is typically assessed by Cronbach's α and composite reliability (CR). As shown in Table 3, Cronbach's α and CR values for each dimension of the model were above 0.7, indicating good reliability[43].

The content of the scales was derived from research findings in relevant literature, combined with the current development of MaaS both domestically and internationally, ensuring good construct validity. As shown in Table 3, the average variance extracted (AVE) was above 0.5 for all dimensions, and factor loadings were above 0.65, indicating good convergent validity of the model. For discriminant validity, the correlation coefficients between the dimensions of the scales were lower than the square roots of their respective AVEs, supporting for the discriminant validity of the measurement model(Table 4). Overall, the scales passed the tests for reliability and validity and can be used for subsequent analysis.

Evaluation of structural model

Structural equation modeling was used to examine the relationship between incentive policies, personal characteristics, and respondents' participation in MaaS. The results of the analysis are presented in Table 5. Overall, the structural model showed a good fit to the data (χ2/df = 1.779, IFI = 0.965, CFI = 0.95, RMSEA = 0.06), indicating that all proposed structural paths were statistically significant. With the exception of hypotheses H2a, H5a, H7a, and H8b, all other hypotheses were supported.

The results of this study indicate that financial incentive policies (β = 0.232, p = 0.004), information policies (β = 0.210, p < 0.01), and convenience policies (β = 0.130, p = 0.04) are significantly positively correlated with the intention to participate in MaaS. Therefore, hypotheses H1a, H3a, and H4a are supported.

Table 2. Sample demographic profile.

Characteristics	Items	Frequency (n = 456)	Percentage (%)
Gender	Male	228	50
	Female	228	50
Age (years)	18–24	142	31.1
	25–34	140	30.7
	35–44	98	21.4
	45–54	54	11.8
	55–64	15	3.2
	≥ 65	7	1.5
Education	High school or below	79	17.3
	Bachelor's degree	227	49.7
	Master's degree or above	150	32.8
Employment status	Enterprise employees	84	18.4
	Administrative staff	75	16.4
	Institution staff	75	16.4
	Students	125	27.4
	Freelancer	47	10.3
	Others	50	10.9
Monthly income (RMB)	< 2,000	80	17.5
	2,000–5,000	92	20.1
	5,001–10,000	129	28.2
	10,001–20,000	108	23.6
	> 20,000	47	10.3
Own private car	Yes	351	76.9
	No	105	23.1
Trip mode	Public transport	197	43.2
	Private car	137	30
	Taxi	20	4.3
	Carpooling	26	5.7
	Bike-sharing	49	10.7
	Walk or bicycle	17	3.7
	Others	10	2.1

Table 3. Results of confirmatory factor analysis.

Construct	Item	Estimate	CR	AVE	Cronbach α
Financial incentive policy	FIP1	0.788	0.778	0.540	0.779
	FIP2	0.721			
	FIP3	0.692			
Non-Financial incentive policy	NFIP1	0.778	0.741	0.588	0.74
	NFIP2	0.756			
Information policy	IP1	0.855	0.896	0.682	0.894
	IP2	0.772			
	IP3	0.821			
	IP4	0.853			
Convenience policy	CP1	0.831	0.867	0.686	0.867
	CP2	0.823			
	CP3	0.83			
Innovation trait	IT1	0.745	0.784	0.548	0.782
	IT2	0.754			
	IT3	0.721			
Habit schema congruence	HSC1	0.883	0.882	0.652	0.879
	HSC2	0.79			
	HSC3	0.783			
	HSC4	0.768			
Environment trait	ET1	0.838	0.898	0.687	0.897
	ET2	0.829			
	ET3	0.835			
	ET4	0.812			
Social influence	SI1	0.882	0.870	0.691	0.869
	SI2	0.816			
	SI3	0.793			
Attitute to MaaS	ATM1	0.831	0.836	0.630	0.839
	ATM2	0.789			
	ATM3	0.76			
Behavior to MaaS	BTM1	0.855	0.796	0.661	0.794
	BTM2	0.769			

Table 4. Discriminant validity analysis.

	FIP	NFIP	IP	CP	IT	HSC	ET	SI	ATM	BTM
FIP	**0.735**									
NFIP	0.473**	**0.767**								
IP	0.532**	0.384**	**0.826**							
CP	0.507**	0.398**	0.436**	**0.828**						
IT	0.429**	0.364**	0.432**	0.414**	**0.740**					
HSC	0.414**	0.350**	0.399**	0.425**	0.417**	**0.807**				
ET	0.535**	0.424**	0.519**	0.506**	0.497**	0.468**	**0.892**			
SI	0.409**	0.357**	0.499**	0.540**	0.315**	0.374**	0.457**	**0.831**		
ATM	0.564**	0.415**	0.574**	0.535**	0.435**	0.520**	0.535**	0.509**	**0.794**	
BTM	0.662**	0.567**	0.616**	0.632**	0.551**	0.584**	0.650**	0.548**	0.708**	**0.813**

***, **, and * represent significance levels of 1%, 5%, and 10% respectively. The diagonal (in bold) represents the value of √AVE.

Table 5. Results of the hypotheses.

Hypothpaesis	Path	Coefficients	*p*-value	Test results
H1a	FIP→ATM	0.232	0.004**	Supported
H2a	NFIP→ATM	0.012	0.847	Rejected
H3a	IP→ATM	0.210	0.000***	Supported
H4a	CP→ATM	0.130	0.04**	Supported
H5a	IT→ATM	0.055	0.353	Rejected
H6a	HSC→ATM	0.213	0.000***	Supported
H7a	ET→ATM	0.057	0.35	Rejected
H8a	SI→ATM	0.141	0.014**	Supported
H1b	FIP→BTM	0.187	0.004**	Supported
H2b	NFIP→BTM	0.190	0.000***	Supported
H3b	IP→BTM	0.085	0.07*	Supported
H4b	CP→BTM	0.130	0.008**	Supported
H5b	IT→BTM	0.103	0.024**	Supported
H6b	HSC→BTM	0.118	0.003**	Supported
H7b	ET→BTM	0.098	0.035**	Supported
H8b	SI→BTM	0.036	0.423	Rejected
H9	ATM→BTM	0.292	0.000***	Supported

***, **, and * represent significance levels of 1%, 5%, and 10% respectively.

Although non-financial incentive policies are also positively correlated with the intention to participate, the results are not significant, thus rejecting H1b. Furthermore, financial incentive policies, non-financial incentive policies, information policies, and convenience policies all have a significant positive impact on participation behavior in MaaS, thus supporting hypotheses H1b to H4b. Additionally, this paper found that financial policies and information policies have a more significant incentive effect. One possible explanation is that financial policies, as a material reward, can directly stimulate users' participation motivation. Furthermore, providing transportation subsidies and other forms of incentives can reduce the cost burden for users who have to travel longer distances. Non-financial incentives did not yield significant results in this study, possibly because the study only considered carbon credits and carbon coins as non-financial incentive measures. Another possible explanation is that non-financial incentives are closely related to carbon emission calculations, and travelers may lack detailed knowledge of them, leading to distrust and unfamiliarity. Moreover, the existing redemption models for non-financial incentives are relatively limited, which may also contribute to their inability to attract travelers.

In terms of individual characteristics of travelers, innovative traits ($\beta = 0.055$, $p > 0.05$), habit schema congruence ($\beta = 0.213$, $p < 0.001$), environmental influence ($\beta = 0.057$, $p > 0.05$), and social influence ($\beta = 0.141$, $p < 0.014$) are all positively related to attitude, but only H6a and H8a are significantly supported. Additionally, personal characteristics have a positive and significant impact on participation behavior in MaaS, except for social influence ($\beta = 0.036$, $p > 0.05$). Thus, H5b, H6b, and H7b are also supported. Attitudes to participate in MaaS also has a significant positive impact on participation behavior, thus supporting H9.Contrary to our expectations, environmental factors do not have a significant impact on users' attitude to participate but show a positive relationship with participation behavior. This could be due to MaaS being a relatively new concept that has not been well promoted and publicized, resulting in limited awareness of its green and low-carbon features. Additionally, although the influence of media and government can enhance users' willingness to participate, there are no significant behavioral outcomes. Therefore, in the future, combining media promotion with actual incentives will be necessary to encourage more users to participate in MaaS travel.

Furthermore, in order to further analyze the willingness of individuals to participate in MaaS based on the incentive policies and personal characteristics, the Bootstrap method was used to estimate the mediating effects in a sample of 2,000 observations at a 95% confidence interval (as shown in Table 6). The results indicated that the mediating effects of financial incentives, information incentives, habit schema congruence, and social influence were significant, suggesting that these factors indirectly influenced the willingness to participate in MaaS through attitudes towards behavior.

Latent profile analysis

In order to better explore the heterogeneity of different user groups in MaaS and their main demographic characteristics, and to provide more targeted incentives for different populations to participate in MaaS, this paper uses Mplus 8.3 to use the 10 dimensions in Table 1 as observed variables for latent

Table 6. Results of the mediation effect.

Path	Effect value	LLCI	ULCI
FIP→ATM→BTM	0.068	0.016	0.160
NFIP→ATM→BTM	0.003	−0.038	0.050
IP→ATM→BTM	0.062	0.022	0.122
CP→ATM→BTM	0.038	−0.008	0.112
IT→ATM→BTM	0.016	−0.029	0.066
HSC→ATM→BTM	0.062	0.021	0.134
ET→ATM→BTM	0.017	−0.025	0.068
SI→ATM→BTM	0.041	0.003	0.097

category analysis and characterized each category[44].

To investigate the potential latent classes of users' participation in MaaS, starting with one class as a baseline, the number of profiles was gradually increased. According to Table 7, the AIC, BIC, and aBIC values progressively decreased with the increase in the number of clusters, and the Bootstrap Likelihood Ratio Test (BLRT) values were significant for all categories. By comparing the models, the five-cluster model showed lower AIC, BIC, and aBIC values than the four-cluster model, and the entropy value was greater than 0.9. Therefore, it is considered that the five-cluster model can better predict respondents' choices in MaaS participation.

In order to further analyze the relationship between each dimension and MaaS participation, this study conducted an analysis of variance (ANOVA) to explore whether there are significant differences between the latent classes in each dimension. From Fig. 2 and Table 8, it can be observed that the five latent classes exhibit significant differences in the classification. Table 9 provides an overview of the final classification indices and demographic indicators, arranged in order of percentage shares.The results show that Cluster 1 has the highest level of positive intention and behavior in MaaS participation. According to post hoc tests, this group has the highest average scores in information incentives, environmental influence, and social influence. Cluster 2 shows reduced willingness compared to Cluster 1, while Cluster 3 has the lowest scores across all categories.Additionally, both Cluster 4 and Cluster 5 demonstrate relatively high intention and behavior in MaaS participation. However, they score the lowest in information incentives and convenience incentives, respectively. Moreover,

Table 7. Model fit statistics.

Number of Clusters	LL	AIC	BIC	aBIC	ENTROPY	LMR(p)	BLRT(p)
1	−6,360.714	12,761.428	12,843.878	12,780.404	–	–	–
2	−5,517.477	11,096.963	11,224.750	11,126.366	0.939	0.000	0.000
3	−5,276.776	10,637.553	10,810.698	10,677.403	0.924	0.000	0.000
4	−5,088.362	10,282.723	10,501.216	10,333.011	0.957	0.090	0.000
5	−4,885.488	9,898.977	10,162.816	9,959.701	0.971	0.002	0.000
6	−4,718.805	9,587.610	9896.797	9658.771	0.952	0.007	0.000

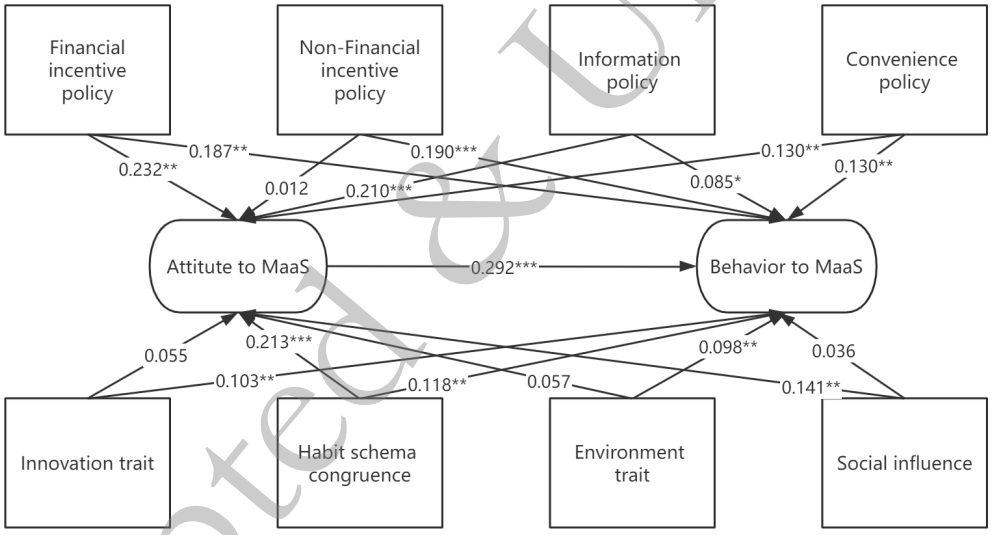

Fig. 2 Results of the hypotheses.

Table 8. Latent profile feature.

Variable	Cluster1		Cluster2		Cluster3		Cluster4		Cluster5		F value ($p \le 0.001$)	Post Hoc Test ($p \le 0.001$)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
FIP	4.19	0.60	3.24	0.84	2.13	0.73	4.44	0.37	4.67	0.33	137.9***	5 > 4 & 1 > 2 > 3
NFIP	3.99	0.76	3.27	0.82	2.50	0.75	4.50	0.36	4.37	0.68	63.509***	4 & 5 > 1 > 2 > 3
IP	4.39	0.42	3.07	0.44	2.36	0.25	1.77	0.27	4.34	0.21	580.705***	1 & 5 > 2 > 3 > 4
CP	4.42	0.35	3.08	0.51	2.29	0.23	4.83	0.23	1.64	0.38	676.122***	4 > 1 > 2 > 3 > 5
IT	4.14	0.60	3.59	0.75	2.58	0.91	4.23	0.91	4.44	0.61	61.921***	5 > 4 & 1 > 2 > 3
HSC	4.06	0.72	3.50	0.82	2.15	0.93	4.38	0.38	4.57	0.37	85.273***	5 > 4 & 1 > 2 > 4
ET	4.23	0.62	3.52	0.76	2.13	0.70	4.20	0.75	4.46	0.46	118.395***	5 & 1 & 4 > 2 > 3
SI	3.25	0.96	2.12	0.90	1.32	0.50	2.61	0.84	2.49	0.96	64.822***	1 > 4 & 5 > 3 > 2
ATM	4.17	0.71	3.28	0.59	1.94	0.67	3.62	0.82	3.78	0.78	121.583***	1 > 5 > 2 > 4 > 3
BTM	4.33	0.55	3.25	0.52	2.07	0.64	4.25	0.66	4.24	0.60	208.954***	1 & 4 & 5 > 2 > 3

***, **, and * represent significance levels of 1%, 5%, and 10% respectively.

Table 9. Profile of the final model.

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5
Cluster size	50.90%	26.50%	11.40%	6.10%	5.10%
Indicators (mean)					
FIP	4.19	3.24	2.13	4.44	4.67
NFIP	3.99	3.27	2.5	4.50	4.37
IP	4.39	3.07	2.36	1.77	4.34
CP	4.42	3.08	2.29	4.83	1.63
IT	4.14	3.59	2.58	4.23	4.46
HSC	4.07	3.50	2.15	4.38	4.57
ET	4.22	3.52	2.13	4.20	4.46
SI	3.24	2.12	1.32	2.61	2.50
ATM	4.16	3.28	1.94	3.62	3.78
BTM	4.33	3.25	2.07	4.25	4.24
Socio-demographics					
Gender					
Male	45.6%	61.9%	46.10%	46.4%	43.4%
Female	54.4%	38.1%	53.80%	53.6%	56.6%
Age					
18–24	32.3%	**29.7%**	**32.60%**	**39.2%**	13.0%
25–34	**34.0%**	28.0%	21.10%	25.0%	**39.1%**
35–44	17.6%	23.9%	28.80%	25.0%	26.0%
45–54	9.9%	14.0%	13.40%	10.7%	17.3%
55–64	4.3%	2.4%	1.90%	0.0%	4.3%
≥65	1.7%	1.6%	1.90%	0.0%	0.0%
Education					
High school or below	14.6%	12.3%	26.90%	21.4%	**43.4%**
Bachelor's degree	**48.7%**	**56.1%**	**48.00%**	**53.5%**	26.0%
Master's degree or above	36.6%	31.4%	25.10%	25.0%	30.6%
Employment status					
Enterprise employees	20.6%	19.0%	9.60%	21.4%	8.6%
Administrative staff	13.3%	15.7%	25.00%	21.4%	26.0%
Institution staff	14.6%	18.1%	19.20%	7.1%	**30.4%**
Students	**31.4%**	**20.6%**	**26.90%**	**35.7%**	13.0%
Freelancer	8.1%	18.1%	3.80%	7.1%	8.6%
Others	11.6%	8.2%	15.30%	7.1%	13.0%
Monthly income (RMB)					
< 2000	22.4%	9.0%	13.40%	21.4%	17.3%
2000–5000	19.8%	19.0%	25.00%	21.4%	17.3%
5001–10000	**26.2%**	**33.0%**	**28.80%**	**28.5%**	21.7%
10001–20000	22.4%	24.7%	25.00%	17.8%	**34.7%**
> 20000	9.0%	14.0%	7.60%	10.7%	8.6%
Own private car					
Yes	71.1%	75.0%	80.1%	76.2%	82.6%
No	28.9%	25.0%	19.9%	23.8%	17.3%
Trip mode					
Public transport	42.3%	53.5%	33.8%	47.7%	39.1%
Private car	28.8%	28.5%	39.6%	25.0%	34.7%
Taxi	3.8%	0.0%	3.3%	5.6%	4.3%
Carpooling	3.8%	3.5%	7.4%	5.1%	8.6%
Bike-sharing	13.4%	3.5%	11.5%	10.7%	8.6%
Walk or bicycle	7.6%	7.1%	2.4%	3.4%	0.0%
Others	0.0%	3.5%	1.6%	2.5%	4.3%
Distance					
< 3 km	9.6%	14.2%	8.2%	7.7%	8.6%
3–5 km	17.3%	25.0%	22.3%	28.0%	17.3%
5–10 km	19.2%	35.7%	36.3%	32.3%	34.7%
10–15 km	28.8%	17.8%	19.8%	16.3%	26.0%
> 15 km	25.0%	7.1%	13.2%	15.5%	13.0%
Purpose					
To and form work	23.0%	21.4%	30.5%	28.4%	21.7%
To and form school	19.2%	35.7%	7.4%	9.9%	8.6%
Entertainment	21.1%	10.7%	25.6%	23.2%	21.7%
Shopping	17.3%	7.1%	14.0%	18.5%	26.0%
Pick up others	5.7%	10.7%	5.7%	8.6%	8.6%
Visiting relatives and friends	3.8%	0.0%	3.3%	0.8%	4.3%
Own business	9.6%	10.7%	8.2%	6.8%	8.6%
Other purposes	0.0%	3.5%	4.9%	3.4%	0.0%

Cluster 5 users have lower scores in the Innovation trait, indicating a lower acceptance of new technologies, making them more likely to reject MaaS travel.

In addition, this study utilized the R3Step method and incorporated personal attributes as covariates in a logistic regression analysis. To ensure the robustness of the results, Cluster 1 was selected as the reference category for the regression. The results are shown in Table 10. The findings indicate that gender, age, education, and income all have significant impacts on the latent classes.

In order to conduct a more comprehensive analysis, we have included users' travel characteristics as covariates in the model and visualized the ownership of private cars, travel modes, travel distances, and travel purposes among different groups in Figs 3–6.

Based on the above analysis, we provide the following names and specific explanations for the five clusters:

Cluster 1 (Actively participating individuals): This cluster represents half of the sample and has values higher than other groups in terms of incentive policies and personal characteristics, indicating the strongest intention to participate in MaaS. In this group, except for non-financial policy and social influence, the average score for all other items is above four points.Thire average score in attitude to MaaS and behavior to MaaS is 4.16 and 4.33, which is the highest among all groups.So they are referred to as "MaaS actively participating individuals." The main age group in this cluster is 25–34 years old (34%) with over one-third of its members still being students. Compared with other clusters, the monthly income distribution of this group is more average, so more users will choose bus transportation (47.7%), most of which are commuting to work (28.4%), followed by leisure and entertainment (23.2%).

Cluster 2 (Mobility neutrals): This second cluster comprises 26.5% of the sample. All the average scores are between 2-3, most of them are near 3.Innovation trait is the highest average score in this group (3.59) and social influence is the lowest one.There is not much difference between Financial incentive policy (3.24) and non-financial policy (3.27). Compared to Cluster 1, the individuals in Cluster 2 are younger, with over 85% of them having received higher education. Notably, this cluster is the only one among the five clusters with a higher number of male respondents (61.9%) compared to female respondents

Table 10. Regression results

Predictor variable	Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	Intercept	SE	Intercept	SE	Intercept	SE	Intercept	SE
Gender	−0.688**	0.238	0.001	0.320	−0.037	0.043	0.091	0.447
Age	0.082	0.097	0.080	0.132	−0.136	0.171	0.233*	0.144
Education	−0.063	0.163	−0.522**	0.239	−0.389	0.285	−0.748*	0.397
Employment status	0.000	0.074	0.035	0.097	−0.085	0.126	−0.008	0.132
Monthly income (RMB)	0.272**	0.093	0.079	0.122	−0.003	0.168	0.160	0.183

***, **, and * represent significance levels of 1%, 5%, and 10% respectively.

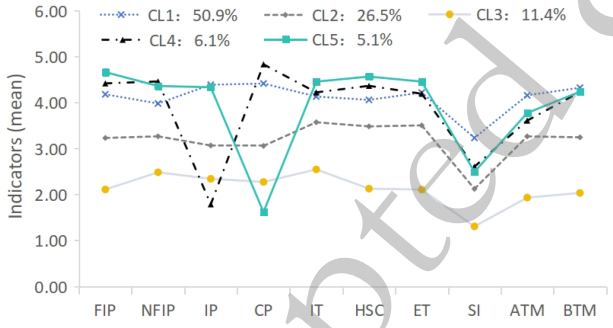

Fig. 3 The distribution of different latent classes

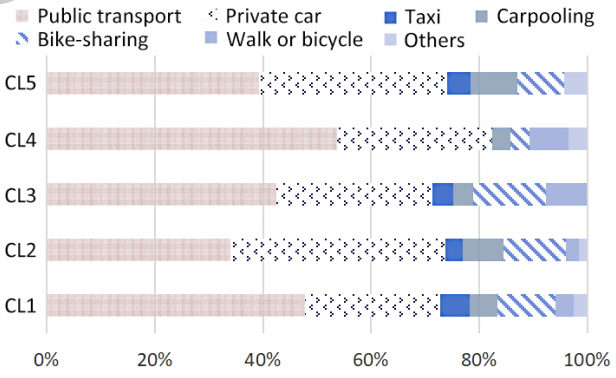

Fig. 5 Travel modes of different latent classes

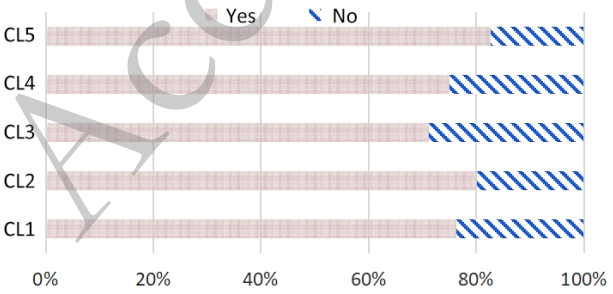

Fig. 4 Ownership of private cars of different latent classes

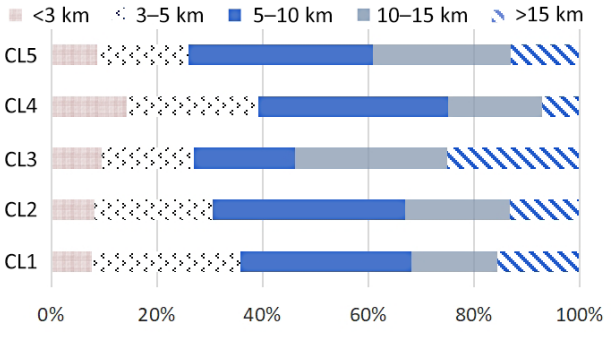

Fig. 6 Travel distance of different latent classes

(38.1%). In terms of travel characteristics, this cluster shows a stronger preference for private cars, with 39.6% of users choosing it as their primary travel mode. The majority of their trips fall within the distance range of 5–10 km (36.3%), and their travel purposes are primarily commuting to work (23%) and going to school (19.2%). Due to their relatively lower willingness to participate in MaaS compared to Cluster 1, they are referred to as "Mobility neutrals."

Cluster 3 (Indifferent individuals): This third cluster represents 11.4% of the total sample. Due to their lowest willingness to participate in MaaS among all clusters and relatively low scores on incentive policies, they are considered "MaaS indifferent individuals." The average scores all around 2 and the scores of social influence and attitude to MaaS are below 2.Financial incentive policy(2.13) and habit schema congruence(2.15) and environment traits(2.13) all have low scores compared with other groups.This cluster has the highest proportion of members (53.8%) who travel more than 10 kilometers among the five clusters, but their ownership of private cars is relatively low (71.1%). The majority of members in this cluster have travel purposes related to commuting to work (23%) or going to school (19.2%). In comparison to the first two clusters, this cluster has a higher percentage of members with a high school education or below (26.9%).

Cluster 4 (Public transport supporters): The fourth cluster (6.1%) is named "Public transport supporters," and their willingness to participate in MaaS is second only to the "Actively participating individuals" cluster.The average score of this category is mostly higher than that of the first category, except for information policy(1.77), which also brings this group low attitude to MaaS(3.26) It is important to note that this cluster has lower scores on information incentive policies than any other cluster, which may be attributed to the fact that the majority of this group is aged between 18-24 years (39.2%) and their primary travel purpose is going to school (35.7%). Despite having private car ownership (75%), taking public transportation is still the most preferred mode for this cluster (53.5%). Therefore, information incentives related to parking spaces and similar aspects might not significantly influence this particular group.

Cluster 5 (Diversified travels): The final cluster represents 5.1% of the total sample. Although it has the smallest number of individuals, this cluster stands out for its significant diversity in travel purposes compared to other clusters. In terms of travel characteristics, shopping (26%), participating in entertainment activities (21.7%), and commuting to work (21.7%) are the top three travel purposes for this cluster. Additionally, this cluster has the highest proportion of individuals using carpooling (8.6%) as their preferred mode of travel. Furthermore, their average innovation trait score is the highest among the five clusters, indicating that they are more open to trying new things and are more likely to participate in MaaS travel. Therefore, this cluster is named "Diversified travels. "This group shows a high interest in the incentive dimension of financial incentive policy (4.67), non-financial incentive policy (4.37), information policy (4.34), innovation traits (4.46), habit schema congruence (4.57) and environment traits (4.46). Despite showing strong interest in both the intention and behavior of participating in MaaS, this cluster scores relatively low in convenience incentives (1.63). This might be due to the fact that a significant portion of this group consists of middle-aged individuals (65.1%) with diverse travel purposes. Despite having a high level of awareness for MaaS participation, 82.6% of users still own private cars, and 34.7% of them prefer private car for their travels.

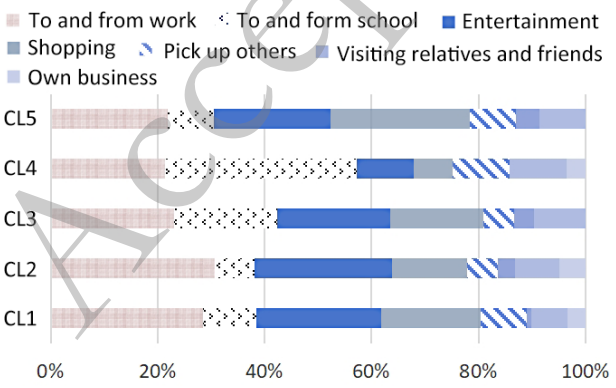

Fig. 7 Travel purposes of different latent classes

Conclusions

Based on different incentive policies, combined with TAM, UTAUT and TRA theory, and comprehensively considering the personal characteristics of users, this paper constructs the MaaS travel intention model under the incentive policy, so as to reveal the incentive policies that affect users' participation in MaaS, and analyzes the structural equation model. On this basis, the group are grouped according to the travel characteristics of different users, and the latent category model. The main conclusions are summarized as follows:

The study found that financial incentive policies, information policies and convenience policies have obvious direct impact on users 'participation in MaaS travel, indicating that the promotion of more users' participation in MaaS is inseparable from the joint efforts of direct financial subsidies and more convenient travel information. Users with innovation and environmental awareness, or travel habits similar to MaaS, are more willing to try to participate in MaaS, while social influence can indirectly affect users' participation behavior through intermediary variables.

As can be seen from the latent category model, different types of users have different preferences for MaaS participation as well as related incentive policies. The 18-34 age group and higher education also showed higher motivation for participating in MaaS, similar to the findings of Narayanan S & Antoniou C[45](2023). In addition, among the three categories with the highest participation, female members are higher than male members, so this paper believes that women prefer and participate in MaaS more than men, which may result from the heterogeneity of different gender preferences for MaaS platform design, content services, etc. In addition, those users with longer travel distance and more travel purposes, despite showing interest in MaaS, may still be a hindering factor in actual participation because information policy and facilitation policy have no significant incentive effect on this part of the group.

Therefore, in the future, on the one hand, the travel platform can expand the way of financial incentives, and provide more diverse exchange options for the travelers who prefer public transportation. In order to encourage more potential users to

join, the platform suppliers can provide more favorable direct financial relief for users who participate in MaaS travel for the first time, and establish the connection between the platform and travelers. On the other hand, in terms of information policy, the platform can cooperate with the government. In addition to incorporating more travel modes into MaaS, the MaaS travel platform can also be combined with scenic spots, ticketing, parking and even cross-city tourism to create a more comprehensive information platform and provide one-stop information services for travelers[46]. Finally, because the user's personal characteristics are closely related to the participation of MaaS, the government or suppliers need to try to promote the concept and service of MaaS, but also need to explain its green, environmental protection and other characteristics, to stimulate the participation of potential users with environmental awareness and expand the audience range of MaaS services.

It is necessary to note several limitations. Firstly, as the development of MaaS, it brings new issues and solutions such as platform privacy and security, fairness, and monopolies[47]. These aspects were not considered in this study. Therefore, future research can further investigate the impact of new incentive policies on user participation in MaaS. Secondly, the sample of this study was limited to Beijing, China. Future research can consider larger samples and broader geographical regions, while also accounting for geographical effects. Another limitation of this study is that it only explores users' willingness to participate in MaaS under incentive policies. In fact, although some groups show enthusiasm for MaaS participation, they may not actually engage in it. Therefore, in the future, it would be beneficial to conduct research and analysis on the actual participation of users under incentive policies.

Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Zhang R, Xiao L; data collection: Zhang R, Ouyang L; analysis and interpretation of results: Zhang R, Xiao L; draft manuscript preparation: Zhang R, Ouyang L, Xiao L. All authors reviewed the results and approved the final version of the manuscript.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request

Acknowledgments

This research was sponsored by The National Natural Science Foundation of China (grant number 71971020).

Conflict of interest

The authors declare that they have no conflict of interest.

Dates

Received 2 February 2024; Accepted 6 June 2024; In press 11 June 2024

References

1. Miskolczi M, Földes D, Munkácsy A, Jászberényi M. 2021. Urban mobility scenarios until the 2030s. *Sustainable Cities and Society* 72:103029
2. Hensher DA, Nelson JD, Mulley C. 2022. Electric car sharing as a service (ECSaaS)–Acknowledging the role of the car in the public mobility ecosystem and what it might mean for MaaS as eMaaS? *Transport Policy* 116:212–16
3. Huang S. 2022. Listening to users' personal privacy concerns. The implication of trust and privacy concerns on the user's adoption of a MaaS-pilot. *Case Studies on Transport Policy* 10:2153–64
4. Lopez-Carreiro I, Monzon A, Lois D, Lopez-Lambas ME. 2021. Are travellers willing to adopt MaaS? Exploring attitudinal and personality factors in the case of Madrid, Spain. *Travel Behaviour and Society* 25:246–61
5. Wang S, Li J, Zhao D. 2017. The impact of policy measures on consumer intention to adopt electric vehicles: Evidence from China. *Transportation Research Part A: Policy and Practice* 105:14–26
6. Hu X, Wang S, Zhou R, Gao L, Zhu Z. 2023. Policy driven or consumer trait driven? Unpacking the EVs purchase intention of consumers from the policy and consumer trait perspective. *Energy Policy* 177:113559
7. Zeiske N, van der Werff E, Steg L. 2021. The effects of a financial incentive on motives and intentions to commute to work with public transport in the short and long term. *Journal of Environmental Psychology* 78:101718
8. Wei J, Zhang L, Yang R, Song M. 2023. A new perspective to promote sustainable low-carbon consumption: The influence of informational incentive and social influence. *Journal of Environmental Management* 327:116848
9. Matowicki M, Amorim M, Kern M, Pecherkova P, Motzer N, Pribyl O. 2022. Understanding the potential of MaaS–An European survey on attitudes. *Travel Behaviour and Society* 27:204–15
10. Ye J, Zheng J, Yi F. 2020. A study on users' willingness to accept mobility as a service based on UTAUT model. *Technological Forecasting and Social Change* 157:120066
11. Aman JJC, Smith-Colin J. 2022. Application of crowdsourced data to infer user satisfaction with mobility as a service (MaaS). *Transportation research interdisciplinary perspectives* 15:100672
12. van't Veer R, Annema JA, Araghi Y, de Almeida Correia GH, van Wee B. 2023. Mobility-as-a-Service (MaaS): A latent class cluster analysis to identify Dutch vehicle owners' use intention. *Transportation Research Part A: Policy and Practice* 169:103608
13. Krauss K, Reck DJ, Axhausen KW. 2023. How does transport supply and mobility behaviour impact preferences for MaaS bundles? A multi-city approach. *Transportation Research Part C: Emerging Technologies* 147:104013
14. Alonso-González MJ, Hoogendoorn-Lanser S, van Oort N, Cats O, Hoogendoorn S. 2020. Drivers and barriers in adopting Mobility as a Service (MaaS)–A latent class cluster analysis of attitudes. *Transportation Research Part A: Policy and Practice* 132:378–401
15. Christensen TH, Friis F, Nielsen MV. 2022. Shifting from ownership to access and the future for MaaS: Insights from car sharing practices in Copenhagen. *Case Studies on Transport Policy* 10:841–50
16. Fenton P, Chimenti G, Kanda W. 2020. The role of local government in governance and diffusion of Mobility-as-a-Service: exploring the views of MaaS stakeholders in Stockholm. *Journal of Environmental Planning and Management* 63:2554–76
17. Vij A, Dühr S. 2022. The commercial viability of Mobility-as-a-Service (MaaS): What's in it for existing transport operators, and why should governments intervene? *Transport reviews* 42:695–716
18. Khan U, Yamamoto T, Sato H. 2020. Consumer preferences for hydrogen fuel cell vehicles in Japan. *Transportation Research Part D: Transport and Environment* 87:102542
19. dos Reis RA, Grant-Muller S, Lovelace R, Hodgson F. 2022. Different people, different incentives? Examining the public acceptance of smartphone-based persuasive strategies for sustainable travel using psychographic segmentation. *International Journal of*

Sustainable Transportation 16:1–21
20. Chen Y, Acheampong RA. 2023. Mobility-as-a-service transitions in China: Emerging policies, initiatives, platforms and MaaS implementation models. *Case Studies on Transport Policy* 13:101054
21. Sochor J, Arby H, Karlsson IM, Sarasini S. 2018. A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. *Research in Transportation Business & Management* 27:3–14
22. Li W, Shibasaki R, Zhang H, Chen J. 2022. MaaS system development and APPs. *Big Data and Mobility as a Service*: 1-24
23. Sakai K. 2020. Public transport promotion and mobility-as-a-service. *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences* 103:226–30
24. Yang Y, Lin S. 2023. *External pressures and internal dynamics of the implementation of MaaS: Case study of Shanghai City Government*. Nord universitet
25. Brezovec P, Hampl N. 2021. Electric vehicles ready for breakthrough in MaaS? consumer adoption of E-car sharing and E-scooter sharing as a part of mobility-as-a-service (MaaS). *Energies* 14:1088
26. Kriswardhana W, Esztergár-Kiss D. 2023. Exploring the aspects of MaaS adoption based on college students' preferences. *Transport Policy* 136:113–25
27. Lopez-Carreiro I, Monzon A. 2023. Exploring travellers' willingness to adopt MaaS in two European metropolitan areas. *Transportation Research Procedia* 72:1885–93
28. Roos JM, Sprei F, Holmberg U. 2022. Traits and transports: The effects of personality on the choice of urban transport modes. *Applied Sciences* 12:1467
29. Hensher DA, Mulley C, Ho C, Wong Y, Smith G, Nelson JD. 2020. *Understanding Mobility as a Service (MaaS): Past, present and future*. Elsevier
30. Seebauer S, Stolz R, Berger M. 2015. Technophilia as a driver for using advanced traveler information systems. *Transportation Research Part C: Emerging Technologies* 60:498–510
31. Fioreze T, De Gruijter M, Geurs K. 2019. On the likelihood of using Mobility-as-a-Service: A case study on innovative mobility services among residents in the Netherlands. *Case Studies on Transport Policy* 7:790–801
32. Schikofsky J, Dannewald T, Kowald M. 2020. Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany. *Transportation Research Part A: Policy and Practice* 131:296–312
33. Dastjerdi AM, Kaplan S, e Silva JdA, Nielsen OA, Pereira FC. 2019. Use intention of mobility-management travel apps: The role of users goals, technophile attitude and community trust. *Transportation Research Part A: Policy and Practice* 126:114–35
34. Tsouros I, Tsirimpa A, Pagoni I, Polydoropoulou A. 2021. MaaS users: Who they are and how much they are willing-to-pay. *Transportation Research Part A: Policy and Practice* 148:470–80
35. Kamargianni M, Li W, Matyas M, Schäfer A. 2016. A critical review of new mobility services for urban transport. *Transportation Research Procedia* 14:3294–303
36. Pritchard J. 2022. MaaS to pull us out of a car-centric orbit: Principles for sustainable Mobility-as-a-Service in the context of unsustainable car dependency. *Case Studies on Transport Policy*
37. Zong F, Li Y-X, Zeng M. 2023. Developing a carbon emission charging scheme considering mobility as a service. *Energy* 267:126495
38. Madigan R, Louw T, Wilbrink M, Schieben A, Merat N. 2017. What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems. *Transportation research part F: traffic psychology and behaviour* 50:55–64
39. Ghasri M, Vij A. 2021. The potential impact of media commentary and social influence on consumer preferences for driverless cars. *Transportation Research Part C: Emerging Technologies* 127:103132
40. Manca F, Sivakumar A, Polak JW. 2022. Capturing the effect of multiple social influence sources on the adoption of new transport technologies and services. *Journal of choice modelling* 42:100344
41. Zhu C, Shou M, Zhou Y, Li W. 2023. Modeling the effect of social media on older adults' usage intention of public transport. *Economic Analysis and Policy* 77:239–50
42. Hair JF. 2009. Multivariate data analysis.
43. Hu Lt, Bentler PM. 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal* 6:1–55
44. Lanza ST, Rhoades BL. 2013. Latent class analysis: an alternative perspective on subgroup analysis in prevention and treatment. *Prevention science* 14:157–68
45. Narayanan S, Antoniou C. 2023. Shared mobility services towards Mobility as a Service (MaaS): What, who and when? *Transportation Research Part A: Policy and Practice* 168: 103581
46. Chen C-F, Fu C, Chen Y-C. 2023. Exploring tourist preference for Mobility-as-a-Service (MaaS)–A latent class choice approach. *Transportation Research Part A: Policy and Practice* 174:103750
47. Enoch M, Potter S. 2023. MaaS (Mobility as a Service) market futures explored. *Transport Policy* 134:31–40