

Article

How Travel-Scenario Factors Shape the Substitution of Ride-Hailing Services by “Metro+” MaaS Intermodal Trips: Evidence from Beijing MaaS

Yan Xu ^{1,*}, Chen Gao ¹, Xiang-Long Liu ^{2,3}, Xiang-Jing Li ^{2,3} and Chang Wang ^{2,3}

¹ School of Economics and Management, North China University of Technology, Beijing 100144, China; chennn0729@126.com

² China Academy of Transportation Sciences, Beijing 100029, China; liuxianglong@motcats.ac.cn (X.-L.L.); lixj@motcats.ac.cn (X.-J.L.); wangchang@motcats.ac.cn (C.W.)

³ Key Laboratory of Advanced Public Transportation Science, Beijing 100029, China

* Correspondence: bnuxuyan@126.com or ncutexuan@ncut.edu.cn; Tel.: +86-10-58801915

Highlights

Please indicate how your work links to systems science via your contributions to systems practice, theory, and/or methodology.

- Identify market opportunities for mobility as a service (MaaS) and validate the value of MaaS for sustainable transportation.
- Support the development of the MaaS ecosystem.

What are the main findings and/or the implications of the main findings?

- The results show that travel-scenario factors significantly affected “Metro+” MaaS intermodal trip adoption for urban medium–long-distance trips.
- For market promotion, MaaS providers should emphasize travel scenarios in their messaging, rather than targeting specific demographic groups.

Abstract

Mobility as a service (MaaS) has emerged as a means to promote multimodal public transport and shared mobility trips, with the “Metro+” integrated mobility approach being its primary form. However, it has recently witnessed major global providers’ bankruptcies. Therefore, this study aims to identify factors driving users’ substitution of ride-hailing by “Metro+” MaaS intermodal trips. Specifically, we took ride-hailing trips as the baseline and constructed a multinomial logit (MNL) model incorporating travel-scenario factors, including trip purpose, weather, and urgency. The results show that travel-scenario factors significantly affected “Metro+” MaaS intermodal trip adoption for urban medium–long-distance trips. Users preferred MaaS intermodal trips for long-distance trips amid clear weather and no time pressure, and they favored ride-hailing in extreme weather conditions or for time-sensitive trips. Therefore, MaaS providers should emphasize travel scenarios in their marketing messaging. Finally, marginal rate of substitution (MRS) and elasticity analyses were conducted, and several strategies were proposed: (1) increasing ride-hailing availability; (2) improving transfer facilities and conditions; and (3) implementing dynamic demand matching. The study facilitates the identification of market opportunities for MaaS instead of car usage, contributes to MaaS marketing and service strategy optimization, and promotes sustainable urban transportation system development.



Academic Editors: Konstantina Anastasiadou and Nikolaos Gavanias

Received: 8 July 2026

Revised: 15 August 2026

Accepted: 17 August 2026

Published: 21 August 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article

distributed under the terms and

conditions of the [Creative Commons](#)

[Attribution \(CC BY\)](#) license.

Keywords: travel scenario; mobility as a service; multinomial logit model; integrated travel; ride-hailing

1. Introduction

The European Union's (EU) Green Deal encompasses a comprehensive framework for tackling climate change, with a commitment to achieving carbon neutrality by 2050. In China, the corresponding policy is the "30-60" Dual Carbon Goals proposed in 2020, namely peaking carbon emissions before 2030 and realizing carbon neutrality before 2060. These goals have been made a national strategy and incorporated into the 14th Five-Year Plan and the Long-Range Objectives through the Year 2035. Under the strict constraints of the Dual Carbon Goals, green transformation has become a key priority for the development of the transportation system. The transport sector represents approximately 10% of China's total carbon emissions and consumes over one-third of the country's petroleum, which is mainly used as transport fuel, making it a vital sector for energy conservation and carbon reduction [1]. Some researchers have reported that multimodal trips are more sustainable than unimodal (i.e., car) trips for controlled distance and that unimodal trips contribute more to CO₂ emissions than the same distance of multimodal trips [2]. Accordingly, a key focus of these green transformation efforts is addressing the dominance of private cars over public transport and encouraging more multimodal trips.

Mobility as a service (MaaS) is a model that integrates different, independently operated transportation modes into a unified system. It is based on shared data infrastructure and accessed through one service interface. Various travel and life service scenarios are connected in this system [3–7]. Through data integration, resources can be allocated and shared efficiently. In this way, travelers gain a one-stop mobility service from origin to destination [1]. MaaS represents a digital, intelligent, and personalized direction for future urban transportation. Since its introduction, it has helped promote sustainable transport and reduced private car use [8–11]. The concept of MaaS was first proposed at the European Intelligent Transport Conference in Helsinki in 2014. Since then, numerous MaaS projects have been implemented in Europe, North America, Asia, and Africa. International platforms, such as Whim and Ubigo, have also provided cross-country services [12].

In China, several representative MaaS initiatives were launched between 2019 and 2020, including Beijing MaaS, Shanghai Suishenxing, and Guangzhou Apollo. These projects have facilitated urban transportation through integrated information sharing, unified payment systems, and carbon incentive mechanisms. For example, in Beijing and Shanghai, home to the largest MaaS projects in China, a digital platform integrates multimodal transport resources, including buses, metro, ferries, taxis, shared bicycles, and parking lots, to provide one-stop closed-loop services covering "pre-trip planning, in-trip navigation, and post-trip incentives." The city government shares core transport data, such as bus, rail transit, and parking resources, with the digital platform. Notably, the platform's mobile application (APP) offers passengers functions, such as real-time bus information, crowd density querying, and integrated transfer route planning, as well as online and offline payment enabled by quick response (QR) codes generated based on credit cards, as shown in Figure 1. The carbon emission reductions achieved via green (eco-friendly) travel during the trip are converted into "carbon credits," which can be redeemed for public transport card recharge codes or shopping coupons for consumption in the MaaS platform. Virtually all of the MaaS projects in China operate under the pay-as-you-go (PAYG) model, except for some customized prepaid mobility bundles developed for tourism scenarios [13]. In accordance with the MaaS maturity classification proposed by Sochor et al., most MaaS

projects in China are roughly at level 2 or level 1.5 [14]. Specifically, MaaS platforms have seen the integration of travel information and payment yet failed to achieve unified booking and scheduling across all transport modes. In July 2025, Beijing MaaS was included in the United Nations Global Best Practice Casebook on Sustainable Transport.

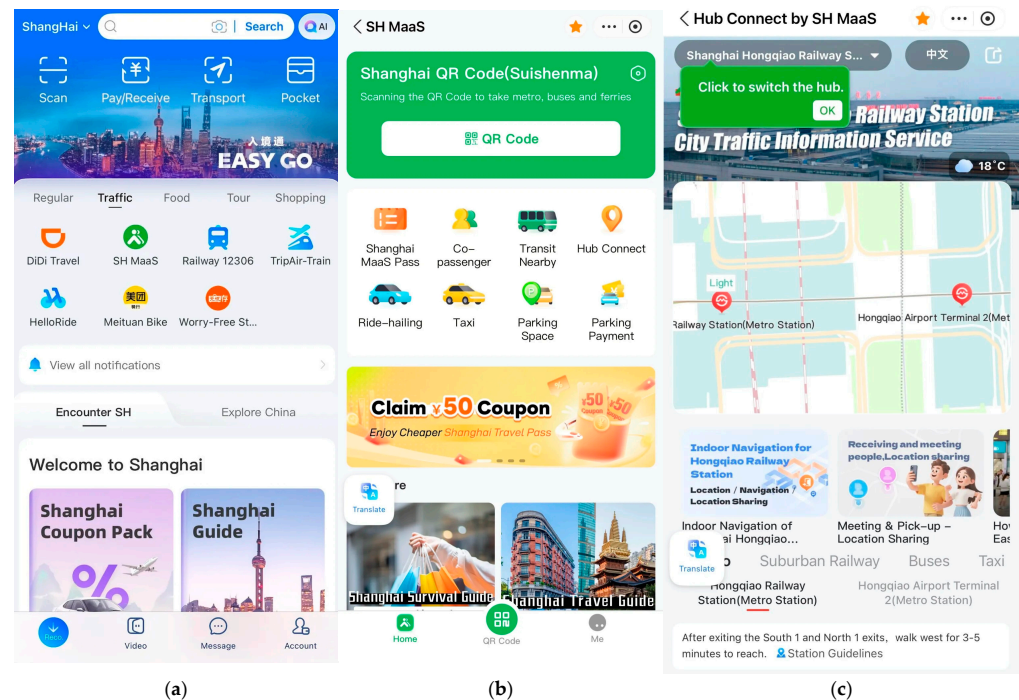


Figure 1. English interface of Shanghai mobility as a service (SH MaaS) application. (a) Homepage of the SH MaaS, an all-in-one digital hub for visitors, which integrates metro, bus, ferry, taxi, and smart parking services in a single entry. (b) The universal quick-response (QR) transit code, known locally as Suishenma, which supports payment for metro, bus, and ferry rides, eliminating the need for separate tickets or multiple service systems. (c) Real-time interactive navigation maps and origin-destination travel information for trip planning. Source: A guide to Shanghai’s all-in-one transport app, Shanghai Municipal Government Foreign Affairs Office, 2025, <https://english.shanghai.gov.cn/en-LatestNews/20251117/2da8d2d6c336475da7d90329c15221d8.html> (accessed on 7 July 2026).

Nevertheless, after more than a decade of development, MaaS adoption remains lower than expected, and its profitability is weak [4,10,15–17]. Owing to difficulties encountered in user scale and resource integration, the international MaaS leading brands Ubigo and Whim had both ceased their operations and filed for bankruptcy by 2024. In China, MaaS is constructed as a digital tool to realize data integration and resource sharing in the transport system, but profitability has not yet been set as its development objective. Nevertheless, the progress of MaaS development has been slower than anticipated. For example, the targets and tasks captured in Beijing’s 14th Five-Year Plan for Smart Transportation propose that the MaaS platform serve over 8 million green trips every day by the end of 2025. In reality, however, the platform served more than 6 million daily green travel users as of October 2025 [18]. This gap inevitably raises the question of whether MaaS genuinely aligns with travelers’ interests and preferences, casting doubt about its feasibility as an alternative to private car travel.

Existing studies on MaaS adoption intention have largely drawn on theories such as the Technology Acceptance Model, the Theory of Planned Behavior, and Cognitive Theory. However, limited attention has been paid to utility comparisons between MaaS and traditional travel modes. For example, Tomaino et al. identified perceived behavioral control, consumer identification, social influence, and perceived cost as key determinants of MaaS

acceptance [19]. Moreover, Schikofsky et al. found psychological factors, such as perceived capability and group identification, as well as the consistency between habitual travel patterns and MaaS use, as significant drivers of travelers' willingness to adopt MaaS [20]. Further, Lopez-Carreiro et al. argued that residents' willingness to adopt intermodal travel, digital technology acceptance, and emerging mobility service reliability are the most important factors affecting MaaS adoption [21]. In addition, most previous studies have focused on the effects of socio-demographic characteristics and trip attributes on MaaS adoption intention, but travel-scenario factors have received less attention. For example, Zijlstra et al. argued that potential MaaS adopters are more likely to be young, highly educated, and high-income people because these groups tend to travel more frequently and use public transport more often [22]. Ho et al. also found infrequent car users to be the most likely adopters and car non-users the least likely adopters [23]. Similarly, Alonso-González et al. evaluated the segmentation characteristics of urban travelers and found that those who made weekly multimodal mixed trips, accounting for one-third of the sample, were the most likely users of MaaS [24]. Regarding MaaS uptake, the study in the Madrid MA showed that nearly 50% of the sample declared a "very high" level of affinity toward the new MaaS solutions. A choice experiment in the Sydney Metropolitan revealed that nearly half of the respondents adopted MaaS offerings [25]. In line with these numbers, 43% of respondents in Finland [26] and up to 46% in Australia [27] expressed interest in MaaS adoption. Comparing these results with the real results of MaaS development, it is evident that existing studies have overestimated travelers' willingness to accept MaaS, as well as the potential of MaaS to replace car trips.

Most of the current research has stemmed from MaaS projects that remain unimplemented or have undergone short-term pilot programs. Moreover, their survey participants have usually lacked practical experience with MaaS and have only been familiar with idealized descriptions of such service. Most existing research has also targeted subscription-based MaaS bundles, while few studies have examined PAYG MaaS cases. Further, limited research has explored the interactive effects among diverse transport modes after large-scale and long-term MaaS deployment. Accordingly, this study aims to undertake a precise evaluation of travelers' willingness to take multimodal trips via MaaS versus unimodal car trips after MaaS deployment. We took the six-year Beijing MaaS scheme as a case and conducted a stated preference (SP) survey on travel intentions in its service coverage. The multinomial logit (MNL) model was adopted to fit travel intentions after comparing the utilities of multiple travel modes.

Given that ride-hailing is the travel mode closest to a private car in terms of time cost and convenience, we used it as a proxy for private car travel. On this basis, the feasibility of integrated MaaS trips as a substitute for ride-hailing was examined, together with the travel scenarios in which such substitution was most applicable during the early stage of MaaS development. Based on these results, this study can help enterprises identify market opportunities for MaaS, assess the value of MaaS for sustainable transportation, and support the development of the MaaS ecosystem.

2. Theoretical Foundations and Research Hypotheses

2.1. Random Utility Theory and the MNL Model

In the market share forecasting field, the MNL model is a classical framework for modeling consumer choice behavior. It has been widely applied in several practical contexts. The model was developed by the American economist Daniel McFadden, who received the Nobel Memorial Prize in Economic Sciences for his contribution. The MNL model is based on random utility theory and assumes that people make consumption decisions by

maximizing utility. By estimating the probability that a person chooses between competing products or services, one can predict market share.

Forecasting travel modal share is an important application of the MNL model because the model's "single choice from multiple alternatives" structure aligns well with the mode or route choice behavior of urban residents. In addition, the MNL model predicts travel demand through individual decision analysis. This approach is more reasonable and has better transferability than traditional traffic analysis zone (TAZ) aggregation methods [16,28–30].

The MNL model first defines a utility function for each travel mode. The utility that person n obtains from choosing mode i can be expressed as follows:

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

$$V_{in} = \theta_i + \sum_{k=1}^K \beta_k X_{ink} \quad (i \in C_n) \quad (2)$$

where U_{in} denotes the total travel utility of person n when choosing mode i , V_{in} is the deterministic component of utility, and ε_{in} signifies the random component. θ_i denotes the alternative-specific constant, β_k represents the estimated parameter for the k -th utility attribute X_{ink} , and C_n denotes the full set of travel modes available to person n , where $i \in C_n$.

It is assumed that the deterministic utility V_{in} and the random error term ε_{in} are independent of each other, and that ε_{in} follows an independently and identically distributed (i.i.d.) Gumbel distribution. Based on utility maximization theory, travelers are assumed to select the alternative with the highest utility. Therefore, person n will choose mode i if $U_{in} > U_{jn}$ for all $j \neq i \in C_n$. On this basis, the logit model for the probability of travel mode choice is formulated as follows:

$$P_{in} = \frac{\exp(V_{in})}{\sum \exp(V_{jn})} \quad (i, j \in C_n) \quad (3)$$

where P_{in} is the probability of person n choosing mode i , while j denotes all of the other travel alternatives excluding i .

Because of its simple structure and well-developed methodology, the MNL model requires a relatively small sample size for calibration. Further, it is less sensitive to initial parameter values and generally converges faster, and its prediction results are stable and often perform better than those of other discrete choice models [31].

The main advantages of the MNL model are twofold. First, it helps explain behavioral mechanisms. By examining the sign, magnitude, and statistical significance of the estimated β coefficients, researchers can spot the key factors that affect travel mode choice and can determine the direction and relative importance of these effects. Second, the model supports policy and strategy simulation. Through elasticity analysis, the model can measure changes in the travel mode choice probabilities caused by changes in utility attributes. In this way, the effects of operational or marketing strategies for mobility service providers can be evaluated in advance.

Existing studies have often built individual travel utility functions by using socio-demographic variables, such as age and income; travel-related attribute variables, such as car ownership, travel time, travel cost, and trip distance; and latent preference indicator variables, such as comfort, convenience, and environmental awareness. These variables have been employed to test the decision-making mechanisms driving the travel mode choice [32].

2.2. Demand Characteristics of Integrated Travel

To construct the travel utility function of the MNL model in a reasonable fashion, in this section, we review and summarize the existing literature on the demand characteristics of MaaS travel. With the gradual implementation of MaaS platforms, including information sharing, payment integration, improved transfer facilities and optimized parking spaces, integrated travel in individual travel chains is expected to increase. Integrated travel represents the major contribution of MaaS to urban transportation. The Annual MaaS Travel Report of Shanghai shows that the “Metro + X” mode dominates MaaS services, with over 70% of MaaS users choosing this intermodal travel combination [33]. The “Metro + X” travel mode refers to intermodal services that integrate metro with buses, shared bicycles, ride-hailing, and other travel modes. Existing studies on integrated travel have mainly focused on transfer motivations, influencing factors, spatiotemporal characteristics, and travel scenarios.

The first focus is transfer motivations. The Annual MaaS Travel Report of Shanghai mentions that shared bicycles can directly serve residential communities, making the “Metro + Shared bicycle” combination a popular travel choice among urban residents. Lu and Zheng assert that during morning and evening peak hours, the travel efficiency of taxis decreases significantly, while metros deliver markedly improved punctuality and rapidity with stable operation schedules. Accordingly, switching from taxis to metro services represents a more efficient travel mode [34]. Based on empirical surveys, Matyas and Kamargianni found that ride-hailing has become an important solution for the “first and last mile” travel [35]. Nevertheless, poor spatial connectivity at transfer stops leads to prolonged waiting times for ride-hailing services, resulting in low travel efficiency [36]. Ao’s study revealed that adverse weather conditions prompted travelers to adjust their original travel modes and to select alternative transport options with the least environmental disruption [37].

The second focus is influencing factors. Schikofsky et al. reported on the impact of psychological, financial and individual factors on the adoption of MaaS [20]. Alonso-González et al. revealed through a case study that car ownership needs and technological capabilities were the main barriers affecting MaaS adoption [24]. Matyas and Kamargianni found that age, gender, income, education and current travel behavior influenced the propensity to purchase MaaS [3]. Further, Chen and Chen showed that the intention to use MaaS was influenced more by mobility convenience than the perceived platform value of informativeness and transaction convenience [38].

The third focus is spatiotemporal dynamics. Wright et al. argued that when journeys are short, less need exists to seek alternatives and multimodal trips [39]. Instead, when traveling times are longer, connection times are a relatively smaller component of overall journey time, and multimodal trip alternatives may result in shorter overall travel time. This assertion suggests that MaaS is suitable for suburban to urban trips. Further, Yu demonstrated that metros were mainly used for medium- and long-distance trips, while ride-hailing was used as an efficient and cost-effective feeder mode for “first and last mile” connections. A clear morning peak was observed in the arrival time of ride-hailing cars at metro stations. The main transfer distance of ride-hailing ranged from 1.5 km to 3.5 km [40]. Cho and Shin found that the bike-sharing use for the access and egress trips to the subway stations at the evening-peak period was more frequent than in other periods [41]. Further, Lu and Zheng examined the feeder relationship between taxis and metros, and their results show that 70% of metro travel was completed in 8 min, while taxi travel routes exhibited a radial distribution pattern [34].

The final area of focus is travel scenarios. The Annual MaaS Travel Report of Shanghai identified three typical types of “Metro + X” integrated travel scenarios: transfers between

parallel metro lines, extensions of single metro line, and expanded radiation coverage of the current rail transit network [33]. Babar et al. analyzed the impacts of ride-hailing on metro ridership for commuting and found ride-hailing to be an important supplementary mode for long-distance metro trips [42]. Qin argued that for outbound commuting trips, commuters prioritize travel punctuality, reliability, and rapidity with reduced sensitivity to travel costs, thereby showing a strong preference for integrated travel. Specifically, the author reported an applicable travel distance for the “Metro + Ride-hailing” mode of 17.9 km to 30 km [43]. Lu and Zheng also found that taxi travel time doubled in central urban areas during traffic congestion periods; in such cases, taxis showed high feasibility for metro connections [34]. Similarly, by analyzing the complementary relationship between free-floating car-sharing service and public transit, Wright et al. suggested that medium- and long-distance commuting in suburban areas is an optimal application scenario for their integrated use [39]. Taking Beijing MaaS as a case study, Huang et al. examined the multimodal combined travel of ride-hailing and metros and found that most “Metro+ Ride-hailing” trips were metro-extended trips, mainly serving commuters in suburban areas without direct metro access [44].

In sum, in the well-connected urban rail transit network, metros have become the main travel mode owing to their time and cost advantages. Buses offer high accessibility to urban residential areas and cost advantages, ride-hailing offers flexible routes and time efficiency, and shared bicycles feature flexible routes and cost advantages. All three of the modes serve as essential complements to metro services. Particularly for medium- and long-distance travel, buses, ride-hailing cars, and shared bicycles play indispensable roles in solving the “first and last mile” problems. Further, the advantages of metro-based integrated travel are more prominent under specific conditions, such as traffic congestion, time urgency, extreme weather, and areas without metro coverage. Therefore, we incorporated the demand characteristics of integrated travel and included travel-scenario factors in the utility function of the MNL model.

2.3. Research Hypotheses

2.3.1. Hypothesis of Travel Scenarios

Both the public transport and shared mobility modes integrated by MaaS possess sharing attributes. Such attributes suggest that in the early stage of MaaS development, the target market is more likely to be defined by specific travel scenarios, rather than specific demographic groups.

In the paper “When is ours better than mine,” Lamberton and Rose pointed out that residents have two main types of travel demand: regular trips (e.g., commuting) and irregular trips (e.g., social and leisure activities). Regular trips are characterized by high frequency and predictability, which makes users more likely to own private cars. In contrast, irregular trips are characterized by lower demand frequency and are more uncertain, making shared mobility a more economical and convenient option [45].

Based on the previous analysis on the demand characteristics of integrated travel (i.e., “Metro + Ride-hailing” and “Metro + Bus”), we incorporated factors, such as travel purpose, weather conditions, and time urgency, into the utility function of MaaS integrated travel. The impacts of these scenario-based factors on travel mode selection and MaaS modal split rate were examined.

Hypothesis 1. *Compared with demographic characteristics, scenario-related factors are more influential predictors of users’ adoption of MaaS integrated travel.*

2.3.2. Travel Purpose Hypothesis

Travel purpose is a critical factor affecting users' MaaS adoption, and diverse travel purposes produce differentiated travel demands. For example, commuters tend to prioritize speed, punctuality, and cost-effectiveness, whereas leisure travelers emphasize travel comfort and flexibility.

Ren's research showed that approximately 40% of ride-hailing orders in Shanghai involved integrated travel with public transport, among which non-commuting trips accounted for 60% and commuting trips accounted for 40% [46]. Further, when exploring the development potential of MaaS in Australia, Harms et al. found that social activities (e.g., dining, watching movies, and bar visits) constituted the dominant travel demand for MaaS usage, while only 20% of respondents adopted MaaS for daily commuting to work or school [47]. In addition, Wang combined MaaS with tourism demand and analyzed the feasibility of applying MaaS to access transportation services at tourist attractions [48].

Hypothesis 2. *Travel purpose significantly influences users' choice of MaaS integrated travel.*

2.3.3. Weather Condition Hypothesis

Weather condition is among the key factors of MaaS travel choices. According to Ao's research, travelers preferred low-carbon travel modes such as walking, cycling, public transport, and electric cars under good weather conditions. Under extreme weather (e.g., scorching heat, extreme cold, rainstorm, snowstorm, or strong wind), travelers tended to shift to the metro, shared cars, and taxis for daily trips [37].

Hypothesis 3. *Weather condition during travel significantly affects users' willingness to choose MaaS integrated travel.*

2.3.4. Time Urgency Hypothesis

Time urgency is yet another key factor affecting users' MaaS adoption. Time urgency stems not only from rigid arrival constraints (e.g., commuting) but also from adverse traffic conditions, such as congestion during peak hours or insufficient transport supply at night in the suburbs.

High time urgency drives travelers to choose faster intermodal options. For example, travelers may switch from taxis to metros during morning congestion, or from metros to taxis in the suburbs at night. Taking the Shenzhen Bay Science and Technology Ecological Park as a case, Zhang demonstrated that a smart MaaS platform could alleviate passenger congestion at metro transit stations and shorten commuting time during peak hours [49]. Consistent with previous results, Lu and Zheng demonstrated that urban road congestion during rush hours greatly reduced taxi efficiency, while metros showed outstanding advantages in travel speed and schedule stability. These results indicate that the transfer from taxis to metro is a more efficient travel alternative [34].

Hypothesis 4. *Time urgency has a significant effect on users' selection of MaaS integrated travel.*

In summary, travel purpose, weather condition, and time urgency jointly influence users' MaaS travel decisions. We included these three types of scenario factors in the travel utility function. Further, these factors were also used as key variables in scenario design. An SP survey was conducted to investigate users' willingness to adopt MaaS integrated travel.

By analyzing travel choices under different scenarios collected from the SP survey, we could identify key influencing factors and test the model performance in this study. Finally, marginal rate of substitution and elasticity analyses were conducted to quantify the

effects of service improvements, such as pricing policies, transfer facility upgrading, and coordinated fleet scheduling for intermodal trips, on the MaaS modal split rate.

3. Materials and Methods

3.1. City Selection and Questionnaire Survey Design

We focused on urban travelers in the central area of Beijing, China's capital city. The city has a well-developed transportation system, including metro, bus, taxi, shared bicycles, pedestrian walkways, and private cars. As of April 2025, the total length of Beijing's urban rail transit network was 1172 km, ranking first in China. Beijing also faces typical urban transport problems, such as traffic congestion and air pollution. Beijing MaaS is the first operational MaaS project in China. In July 2025, it was chosen as the only MaaS project to be included in the United Nations Global Sustainable Transport Best Practices Compilation, marking its international recognition as a leading example of sustainable urban mobility. These features made Beijing a suitable case for analyzing MaaS travel mode choice behavior. Although "Metro + Shared bicycle", "Metro + Ride-hailing", and "Metro + Bus" constitute the main intermodal travel modes of MaaS, statistical evidence presented in the China Major Urban Traffic Analysis Report shows that the transfer coefficient of ground public transport has not increased noticeably after the introduction of MaaS; instead, it has exhibited a gradual downward trend. Furthermore, given the considerable discrepancies between "Metro + Bus" and full-trip ride-hailing in terms of route flexibility, travel time and travel cost, "Metro + Bus" is excluded from the scope of this study. This paper only takes "Metro + Shared bicycle" and "Metro + Ride-hailing" as representatives of MaaS intermodal travel to investigate their substitution relationship with ride-hailing trips.

In this research, 400 questionnaires were distributed through the Credamo data platform in December 2025. Moreover, strict screening was conducted based on the response duration, IP addresses, and embedded attention check questions, and a final valid sample of 314 questionnaires was obtained. The results of the descriptive statistical analysis are given in Table 1.

3.2. Design of Travel Scenario Combinations

To meet the independence of irrelevant alternatives (IIA) assumption of the MNL model, we applied an orthogonal design. This method ensures significant differences between alternatives and reduces multicollinearity between variables [32].

The questionnaire was designed using the orthogonal experimental method, and multiple-choice sets were constructed. Each set contained several travel modes, and each option was defined by attributes with different levels. As shown in Table 2, five key attributes were chosen: travel distance, travel purpose, date type, weather condition, and time urgency. Each attribute had two or three levels.

SPSS 29.0 was employed to generate the orthogonal design. Unreasonable or unrealistic combinations (e.g., commute trips on non-workdays) were removed. Finally, 12 valid travel scenarios were kept. These scenarios were included in the SP questionnaire, resulting in 3768 valid observations for the analysis.

The coding rules and definitions of variables are summarized in Table 3. These variables included socio-demographic variables, travel characteristics, and the scenario-based variables proposed in the hypotheses. For scenario settings, referring to existing studies, we defined two travel purposes (commuting and leisure), two date types (workday and non-workday), three weather conditions (sunny, windy/rainy/snowy, and extreme high/low temperature), and two levels of time urgency (with or without strict time constraints).

Table 1. Descriptive Statistics of the Samples.

Attribute	Category	Sample Size	Proportion	Attribute	Category	Sample Size	Proportion
Gender	Male	166	52.9%	Education	Junior high school and below	1	0.3%
	Female	148	47.1%		High school/vocational high school	7	2.2%
Age	≤20	7	2.2%		College	8	2.5%
	21–30	199	63.4%		Bachelor’s degree	158	50.3%
	31–40	81	25.8%		Master’s degree and above	140	44.6%
	41–50	18	5.7%	Occupation	Student	92	29.3%
	51–60	8	2.5%		Government & public institution staff	48	15.3%
	≥60	1	0.3%		Private enterprise employee	103	32.8%
Monthly Income	<3000 Chinese yuan (CNY)	59	18.8%		State-owned enterprise employee	57	18.2%
	3000–5000 CNY	39	12.4%		Others	14	4.5%
	5000–10,000 CNY	104	33.1%	Available Private Cars in Beijing	0	160	51.0%
	10,000–15,000 CNY	67	21.3%		1 or more	154	49.0%
	>15,000 CNY	45	14.3%				

Table 2. Orthogonal design for travel scenario attributes.

No.	Attributes				
	Travel Distance	Travel Purpose	Date Type	Weather Condition	Time Urgency
1	>20 km	Commute	Workday	Extreme weather	No
2	>20 km	Leisure	Workday	Clear weather	Yes
3	>20 km	Leisure	Non-workday	Windy, rainy, or snowy	No
4	>20 km	Commute	Workday	Clear weather	Yes
5	10–20 km	Leisure	Workday	Windy, rainy, or snowy	Yes
6	10–20 km	Commute	Workday	Clear weather	Yes
7	10–20 km	Leisure	Non-workday	Extreme weather	Yes
8	10–20 km	Commute	Workday	Clear weather	No
9	<10 km	Leisure	Non-workday	Extreme weather	Yes
10	<10 km	Commute	Workday	Clear weather	No
11	<10 km	Leisure	Non-workday	Windy, rainy, or snowy	No
12	<10 km	Commute	Workday	Windy, rainy, or snowy	No

Note: Extreme weather refers to conditions, such as scorching heat, extreme cold, rainstorm, snow-storm, or strong wind.

Previous transportation research has shown that walking is mainly used for trips in 3 km, while other nonmotorized modes are common in 5 km. Trips longer than 5 km are mainly served by motorized and public transport modes [50]. As this study focuses on replacing private car use, only trips of 5 km and above were considered. That is,

nonmotorized modes such as walking were excluded. In this travel distance range, based on the passenger flow characteristics captured in the Shanghai MaaS Annual Mobility Report, three travel modes were included in the modes: two MaaS-based multimodal options (Metro + Shared bicycle, Metro + Ride-hailing), and one single mode (Ride-hailing). These options were used for the travel mode split rate estimation.

Table 3. Variable coding and definitions.

Variable Category	Code	Variable	Definition and Coding
Socio-demographic Factors	GEN	Gender	GEN_1 = Male; GEN_2 = Female
	AGE	Age	AGE_1 = Under 20; AGE_2 = 21–30; AGE_3 = 31–40; AGE_4 = 41–50; AGE_5 = 51–60; AGE_6 = Over 60
	EDU	Education	EDU_1 = Junior high school and below; EDU_2 = High school; EDU_3 = College; EDU_4 = Bachelor’s degree; EDU_5 = Postgraduate and above
	JOB	Occupation	JOB_1 = Student; JOB_2 = Government & public institution; JOB_3 = Private enterprise; JOB_4 = State-owned enterprise; JOB_5 = Others
	INC	Gender	GEN_1 = Male; GEN_2 = Female
Travel Characteristics	CAR	Number of available private cars	CAR_1 = One or more; CAR_2 = None
	DIST	Travel distance	DIST_1 > 20 km; DIST_2 = 10–20 km; DIST_3 < 10 km
	TIME	Travel duration	Continuous variable
	FEE	Travel cost	Continuous variable
Scenario Factors	PUBP	Travel purpose	PUBP_0 = Commute; PUBP_1 = Leisure
	DATA	Date type	DATA_0 = Workday; DATA_1 = Non-workday
	WEAT	Weather condition	WEAT_1 = Clear weather; WEAT_2 = Windy, rainy or snowy; WEAT_3 = Extreme weather
	ARR	Time urgency	ARR_0 = with Time urgency; ARR_1 = without Time-urgency

4. Results

4.1. Heterogeneity of Travel Mode Choice Across Demographic Characteristics

To test Hypothesis 1, we conducted statistical analysis using SPSS. One-way ANOVA was applied to variables with over two categories, while independent-sample t-tests were used for binary variables. The detailed results are given in Table 4. The critical values at the significance level of $\alpha = 0.05$ are listed in the seventh column. Except for monthly income, the F-statistics of all of the demographic variables were lower than the corresponding critical values, indicating no statistically significant differences. In other words, demographic characteristics excluding monthly income exerted no significant influence on travelers’ mode choice.

Figure 2a,b shows the proportional distribution of travel modes across different age and occupation groups, while Figure 2c,d presents the distribution under different weather conditions and time urgency levels. From these figures, we can observe that the modal split rate of MaaS integrated travel and ride-hailing remained relatively stable among diverse demographic groups. However, clear differences emerged under different travel scenarios. For example, the share of ride-hailing increased to 50%, 40%, and 38% under rainy and snowy weather, extreme weather, and time-constrained trips, respectively. These

values are much higher than the 13% seen under clear weather, as well as the 29% for non-time-constrained trips.

Table 4. Socio-demographic Variables with Insignificant ANOVA Results.

Indicator		Sum of Squares	Degrees of Freedom	Mean Square	F-Value	Critical F-Value	p-Value
Age	Between groups	6.263	5	1.253	2.184	2.21	0.053
	In groups	3639.069	6346	0.573			
	Total	3645.332	6351				
Education	Between groups	4.23	4	1.058	1.844	2.37	0.118
	In groups	3641.102	6347	0.574			
	Total	3645.332	6351				
Occupation	Between groups	6.992	6	1.165	2.032	2.36	0.058
	In groups	3638.34	6345	0.573			
	Total	3645.332	6351				

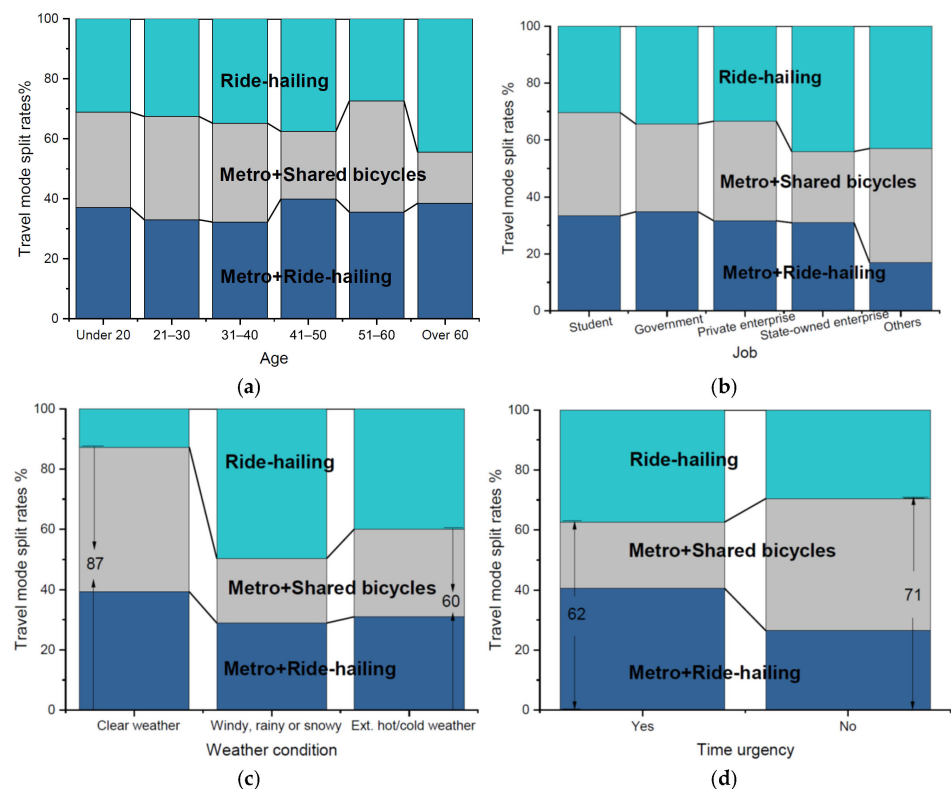


Figure 2. Comparison of disparities in travel mode choice distribution: (a) Travel mode split rate distribution across age groups. (b) Travel mode split rate distribution across occupations. (c) Travel mode split rate distribution under different weather conditions. (d) Travel mode split rate distribution in scenarios with/without time urgency. Source: authors' own elaboration based on the data from this study.

These results show that demographic characteristics did not significantly affect users' choice of MaaS integrated travel. This result partially supports Hypothesis 1.

4.2. Mechanism of Integrated Travel Choice

Socioeconomic attributes, travel-related attributes, and travel scenario attributes were chosen as explanatory variables in the travel mode utility function. Three MNL models (M1, M2, and M3) were constructed for comparison:

Model M1 includes only socioeconomic and travel-related variables;

Model M2 excludes socioeconomic factors and includes travel-related and scenario variables;

Model M3 includes all three variable categories.

We took ride-hailing as the reference alternative, and the parameter estimation results for two MaaS multimodal modes (“Metro + Shared bicycle” and “Metro + Ride-hailing”) are shown in Table 5. Note that in the variable correlation analysis conducted before model parameter fitting, strong correlations were detected between travel distance, travel duration, and travel cost. Accordingly, travel duration was adopted as a substitute for the other two variables. Therefore, only private car availability and travel duration were included in the final regression results. Overall, the McFadden Pseudo-R² values of M1, M2, and M3 all exceeded 0.2, indicating an acceptable model fitness.

Notably, M2 and M3 exhibited markedly improved statistical indicators compared with M1. This result suggests that including scenario variables improves the explanation of travel decisions. In addition, most socioeconomic variables in M1 and M3 were statistically insignificant. This result further supports Hypothesis 1.

Combined with the research hypotheses, the main results are summarized as below:

- (1) Hypothesis 2, which states that travel purpose affects MaaS integrated travel choice, is rejected.

In M2 and M3, the two variables representing travel purpose (commuting trip vs. leisure trip, and workday trip vs. non-workday trip) exhibited low statistical significance. Specifically, the estimated coefficients of the commuting/leisure trip variable in the utility function of the “Metro + Ride-hailing” mode for Models M2 and M3 were -0.111 and -0.123 , respectively, both of which fail to pass the significance test. For the utility function of “Metro + Shared bicycle” mode, the corresponding coefficients were 0.369 and 0.359 , which are also statistically insignificant. As for the weekday/non-workday trip variable, its coefficients in the “Metro + Ride-hailing” utility function of M2 and M3 were -0.087 and -0.085 , neither reaching statistical significance. Significant effects were only observed in the “Metro + Shared bicycle” utility function of M2 and M3, with coefficients of -3.539 and -3.533 correspondingly. These results show that travel purpose was not a decisive factor shaping residents’ MaaS integrated travel choices.

A reasonable explanation for this result is the wide coverage of metro and ride-hailing services in Beijing. That is, the metro-based integrated travel modes can satisfy both daily commuting and leisure trips. Accordingly, urban residents did not exhibit clear differences in travel mode choices across various travel purposes.

- (2) Hypothesis 3, which states that weather conditions during trips affect MaaS integrated travel choice, is supported.

The fitted coefficients of M2 and M3 reveal that rainy/snowy weather and extreme weather both exerted negative effects on the selection of MaaS integrated travel, and the absolute values of coefficients for extreme weather were consistently larger than those for rainy/snowy weather. Specifically, the fitted coefficients of the rainy/snowy weather variable in the utility function of “Metro + Ride-hailing” for Models M2 and M3 were -3.386 and -3.381 , respectively, with both being statistically significant at the 1% significance level ($p < 0.01$). In the utility function of “Metro + Shared bicycle” under Models M2 and M3, the corresponding coefficients were -1.529 and -1.512 , thus also having strong statistical significance. Similarly, the coefficients of extreme hot/cold weather in the “Metro + Ride-hailing” utility function of Models M2 and M3 were -3.592 and -3.628 , indicating significant adverse impacts. For the “Metro + Shared bicycle” travel alternative, the coefficients reached -5.619 and -5.659 , which are also statistically significant.

These results show that rainy/snowy weather and extreme weather both prompted residents to opt for ride-hailing services, instead of MaaS integrated travel modes. Extreme hot or cold weather imposed a stronger negative influence on MaaS integrated travel than rainy and snowy weather. In contrast, under clear weather conditions, travelers were more inclined to abandon ride-hailing and switch to transfer-involved MaaS alternatives, which take slightly longer yet offer superior economic efficiency.

Table 5. Estimation results of travel mode utility functions.

Variable Category	Variables	M1		M2		M3	
		Metro + Ride-Hailing	Metro + Shared Bicycle	Metro + Ride-Hailing	Metro + Shared Bicycle	Metro + Ride-Hailing	Metro + Shared Bicycle
Socioeconomic attributes	Male	−0.192	0.095			−0.24	0.117
	Under 20	0.084	1.697			−0.51	1.224
	21–30 years	0.187	2.025			−0.364	1.675
	31–40 years	0.222	2.129			−0.369	1.795
	41–50 years	0.682	1.805			0.02	1.289
	51–60 years	0.537	1.96			0.052	1.617
	Junior high school and below	−1.455	0.636			−2.821	0.625
	High school/vocational high school	0.647	1.83 *			0.264	1.616
	College	0.036	0.287			−0.037	0.247
	Bachelor’s degree	−0.102	0.077			−0.128	0.065
	Student	−0.536	−0.135			−0.537	−0.124
	Government & public institution	0.118	0.377			−0.036	0.252
	Private enterprise staff	−0.008	0.364			−0.021	0.403
	Other occupations	−0.353	−0.265			−0.283	−0.206
	Monthly income <3000 CNY	0.81 *	0.876 *			0.827	0.972
	3000–5000 CNY	0.786 *	0.651			0.914 *	0.802
	5000–10,000 CNY	0.384	0.5 *			0.41	0.548 *
	10,000–15,000 CNY	0.071	0.024			0.067	0.001
Travel-related attributes	Travel time	0.221 ***	0.293 ***	0.327 ***	0.416 ***	0.327 ***	0.416 ***
	Private car availability	0.149	0.319 *	0.239	0.477 ***	0.166	0.37 *
Travel scenario attributes	Commuting trip			−0.111	0.369	−0.123	0.359
	Workday trip			−0.087	−3.539 ***	−0.085	−3.533 ***
	Rainy and snowy weather			−3.386 ***	−1.529 ***	−3.381 ***	−1.512 ***
	Extreme weather			−3.592 ***	−5.619 ***	−3.628 ***	−5.659 ***
	Time urgency			−2.082 ***	−3.981 ***	−2.082 ***	−4.015 ***
Sample Size		3768		3768		3768	
Significance		0		0		0	
Log-likelihood		3535.055		3454.974		3568.153	
McFadden Pseudo-R ²		0.671		0.745		0.752	

Note: Asterisks indicate statistical significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

- (3) Hypothesis 4, which states time urgency affects MaaS integrated travel choice, is supported.

The estimation results of M2 and M3 show that time urgency exerted a significant negative effect on the adoption of MaaS integrated travel. Specifically, the fitted coefficient of the time-urgent trip variable in the utility function of the “Metro + Ride-hailing” alternative was -2.082 for both Model M2 and M3, which is statistically significant at the 1% level ($p < 0.01$). In the utility function corresponding to the “Metro + Shared bicycle” travel scheme, the coefficients were -3.981 and -4.015 for Models M2 and M3, respectively, also showing strong statistical significance. These results demonstrate that travelers tended to choose ride-hailing services when facing an extremely tight travel schedule. In contrast, people with flexible schedules were more willing to choose transfer-based MaaS integrated travel modes.

In addition, further regression outcomes indicate several key findings: Travelers are more likely to adopt MaaS integrated travel modes for long-distance and time-consuming trips. Private car ownership negatively affects the willingness to use MaaS integrated travel, and this inhibitory effect is significant even for households with one car, and no further increase is observed with more cars. In terms of income, low-income groups show a slightly positive tendency to choose MaaS multimodal travel, although this effect is only weakly significant.

4.3. Analysis of MaaS Promoting Strategies

4.3.1. Marginal Rate of Substitution Analysis

Based on the estimation results of model M3, a marginal rate of substitution (MRS) analysis of travel utility was performed for different travel modes. Table 6 shows the increase in travel time that produced the same negative utility as changes in time urgency and weather conditions.

Table 6. Marginal rates of substitution between travel-scenario factors and travel time.

Changes in Travel-Scenario Factors	Travel Time/min		Opportunity Cost/¥ (RMB)	
	Metro + Ride-Hailing	Metro + Shared Bicycle	Metro + Ride-Hailing	Metro + Shared Bicycle
No time urgency → Time urgency	6.36	9.65	11.06	16.79
Clear weather → Windy/Rainy/snowy weather	10.34	3.63	17.99	6.32
Windy/Rainy/snowy weather → Extreme weather	11.09	13.60	19.29	23.66

Following the method of Ge et al. [51], we estimated the average time cost of residents using Beijing’s per capita GDP in 2025, and the time cost was converted into an opportunity cost of 1.74 yuan per minute. Based on this approach, the opportunity cost loss associated with choosing MaaS integrated travel under different travel scenarios was calculated.

Taking the change from no time urgency to time urgency as an example, we found that the perceived negative utility was equivalent to an increase of 6.36 min in the travel time cost of “Metro + Ride-hailing” and 9.65 min in the travel time cost of “Metro + Shared bicycle.” Under this condition, if travelers chose ride-hailing for the entire trip, they were willing to accept a price difference of 11.06 yuan higher than that of “Metro + Ride-hailing” or 16.79 yuan higher than that of “Metro + Shared bicycle.” The same logic applied when

weather conditions worsened. In such cases, after comparing time and cost, users tended to choose ride-hailing for the entire trip.

4.3.2. Elasticity Analysis

Elasticity analysis is employed to analyze how travel mode split rates respond to changes in various influencing factors. The MRS analysis results indicate that changes in various travel-scenario factors can be converted into increases in travel time. Therefore, this section focuses on the changes in travel mode split rate when travel time increases.

Direct elasticity reflects the correlation between the change in the split rate of mode i and the change in a certain attribute X_{ik} , while indirect elasticity reflects the correlation between the change in the split rate of other travel modes i' due to a change in the same attribute X_{ik} . The specific elasticity calculation formulas can be expressed as follows:

Direct elasticity:

$$\eta_{X_{ik}}^{P_i} = \beta_k X_{ik} (1 - P_i) \quad (4)$$

Indirect elasticity:

$$\eta_{X_{ik}}^{P_{i'}} = -\beta_k X_{ik} P_i \quad (5)$$

where β_k is the coefficient of the k -th variable of travel mode i , X_{ik} is the expectation of the k -th variable of travel mode i , and P_i denotes the selection probability of travel mode i .

Figure 3 shows the direct and indirect elasticities of travel time for three travel modes: “Metro + Ride-hailing,” “Metro + Shared bicycle,” and Ride-hailing travel. The results show that when travel time increased, a portion of passengers taking “Metro + Shared bicycle” or Ride-hailing would shift to the “Metro + Ride-hailing.” Specifically, a 1% increase in travel time reduced the travel split rate of “Metro + Shared bicycle” from 32% to 26.2%, and the travel split rate of Ride-hailing fell from 18.4% to 15.1%. The selection probability of “Metro + Ride-hailing” increased from 49.6% to 58.8%.

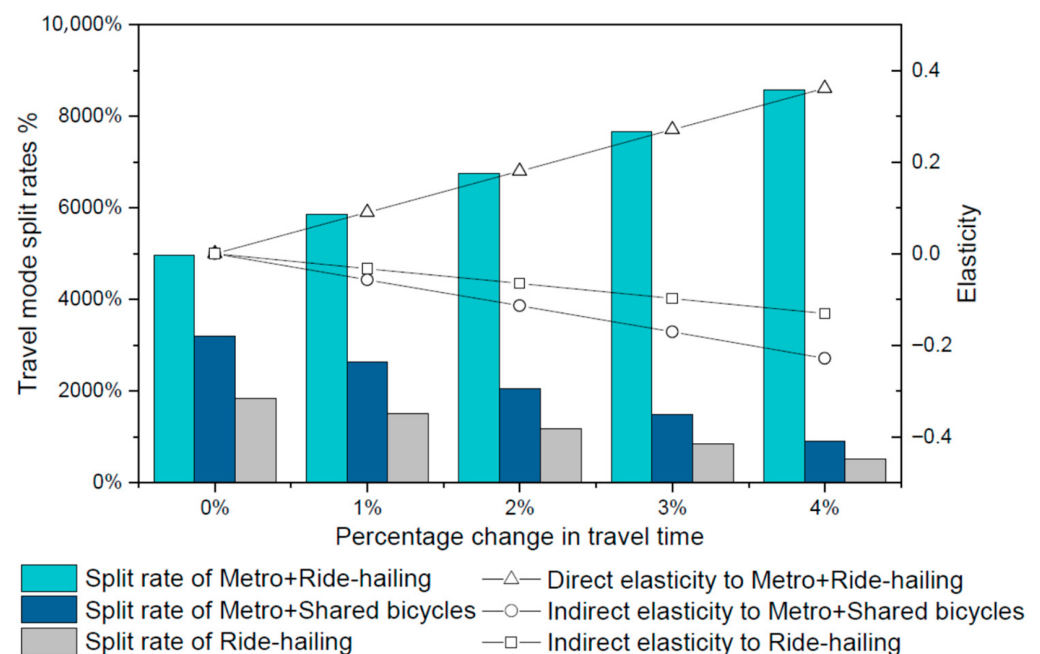


Figure 3. Relationship and elasticity values between travel time and travel mode split rates. Source: authors’ own elaboration based on the data from this study.

The indirect elasticity of travel time on “Metro + Shared bicycle” or Ride-hailing was negative, while the direct elasticity on “Metro + Ride-hailing” was positive. This result reveals that a longer travel time made “Metro + Ride-hailing” more attractive. This result

can be explained by cost trade-offs. For long-distance trips, “Metro + Shared bicycle” involved a high time cost, while Ride-hailing had high monetary cost. The “Metro + Ride-hailing” mode provided a balance between time and cost. As a result, more travelers chose this mode as travel distance and time increase.

4.3.3. Implications for Practice

The results of substitution analysis and elasticity analysis provide important insight for MaaS designers and policy makers. First, the results in Table 6 have clear implications for enterprises’ pricing strategies. Notably, in time-urgent trips (e.g., commuting to work, catching trains, or planes) or trips in rainy, snowy, or extreme weather, it is reasonable for ride-hailing enterprises to maintain the price difference between ride-hailing fares and MaaS tickets in the opportunity cost range shown in Table 6. The opportunity costs in Table 6 can serve as a pricing reference for ride-hailing enterprises.

Second, for MaaS service operators, in these scenarios, suspending low-price strategies and improving users’ negative perceptions of the long transfer time of combined travel by optimizing transfer conditions and car dispatching represent more effective strategies. The existing low-price strategies of MaaS, such as exchanging environmental protection points for gifts or coupons, as well as providing users with subsidies or discounts, are not highly feasible. This is because users attach high value to the time cost difference between MaaS and ride-hailing. Therefore, during morning and evening peak hours, as well as during severe or extreme weather, the dispatching of ride-hailing cars around subway stations can be appropriately increased. Similarly, the frequency of subway services can be adjusted. Finally, the services of MaaS can be matched with real-time changes in travel demand. This approach can improve transfer conditions and facilities for time-urgent trips, eliminate users’ negative perceptions of the time cost of integrated travel, and enhance the attractiveness of MaaS.

Third, combined with the results of elasticity analysis, the longer the travel distance and time, the more passengers transition to the “Metro + Ride-hailing” integrated travel mode. MaaS operators should raise the ride-hailing supply near subway stations, particularly in areas far from the city center. Improving the transport capacity and coordination of “Metro + Ride-hailing” service for long-distance trips can improve the flexibility and quality of MaaS services.

5. Conclusions

We focused on travel scenarios as the main influencing factors and established an MNL model to analyze travelers’ choices of MaaS integrated travel and its substitution effect on full-ride ride-hailing travel. Several key findings emerge from the empirical results of this study. Travel mode choices exhibit little variation across different demographic groups but change significantly across travel scenarios. Characteristics of travel scenarios can serve as critical market segmentation criteria in the initial development phase of MaaS, and some specific scenarios represent target markets that MaaS operators should actively explore. Furthermore, scenario factors such as weather conditions and time urgency significantly affect the choice of MaaS multimodal travel. Specifically, for long-distance trips under clear weather with no time urgency, travelers favor MaaS integrated travel. Conversely, in travel scenarios with rainy, snowy, or extreme hot/cold weather, or with time urgency requirements, travelers favor full-ride ride-hailing travel, and MaaS integrated travel cannot fully replace ride-hailing. Marginal rate of substitution and elasticity analyses indicate that existing low-price strategies of MaaS operators hold limited appeal in special travel scenarios. Enhancing transport capacity, improving transfer facilities, and increasing transfer efficiency can reduce users’ perceived time costs and increase the travel split rate of

MaaS multimodal travel. In addition, the longer the travel time, the higher the probability of choosing “Metro + Ride-hailing” travel. Similarly, the transport capacity of ride-hailing cars can be increased around suburban subway stations to increase the appeal of MaaS multimodal travel.

Based on the verification of the impact of travel-scenario factors on travelers’ choice of MaaS combined travel, we posit that the target market of MaaS should lie in specific travel scenarios, rather than in specific demographic groups. The empirical analysis results further indicate the characteristics of travel scenarios for MaaS combined travel. The study’s empirical results can not only improve the positioning and market promotion of MaaS in the initial development stage, but they can also serve as a reference for optimizing service strategies, such as pricing, connection and transfer, and operation scheduling of MaaS multimodal travel.

We acknowledge certain study limitations that can be addressed in future research. First, considering the travel characteristics of Beijing’s transport system, we only examined the potential of two travel modes—“Metro + Shared bicycle” and “Metro + Ride-hailing”—to substitute private car trips. Considering the goal of MaaS is to integrate all of the transport modes to deliver an integrated travel experience, future research may thus incorporate additional travel alternatives such as “Metro + On-demand Transport”, “Metro + Private Car (static mobility services)” and “Metro + Robotaxi,” and it can explore their impacts on private car-based trips. Second, we only evaluated the service area of Beijing MaaS. The results were obtained under the conditions of the PAYG MaaS model at the Level 2 stage. Thus, future studies should take into account the similarity with the Beijing MaaS project when drawing on our results. Further research in other MaaS projects will be useful to establish the generalizability of the study results.

Author Contributions: Conceptualization, Y.X.; methodology, C.G.; software, C.G.; validation, Y.X. and C.G.; formal analysis, C.G.; investigation, C.G. and X.-J.L.; resources, X.-L.L. and X.-J.L.; data curation, C.W.; writing—original draft preparation, Y.X.; writing—review and editing, Y.X. and X.-J.L.; visualization, Y.X.; supervision, X.-L.L.; project administration, X.-L.L.; funding acquisition, X.-L.L. and Y.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by (1) Humanities and Social Sciences Fund of Ministry of Education of China, grant number 21YJAZH098; (2) Open Project of the Academy of Sciences of the Ministry of Transport, grant number 2023-APTS-04; (3) Project of Cultivation for Young Top-motch Talents of Beijing Municipal Institutions, grant number BPHR202203040. The APC was funded by Open Project of the Academy of Sciences of the Ministry of Transport, grant number 2023-APTS-04.

Institutional Review Board Statement: This study was conducted in accordance with Charter of the Science and Technology Ethics Committee of North China University of Technology. No approval from the Institutional Ethics Committee was required, as the data obtained from the research was only reported in aggregate, and procedures make individual subject identification improbable. Samples were collected anonymously with no personal privacy data included in questionnaires. In particular all subjects were informed that they are not required to complete the research study. Therefore, ethics approval is not required for this type of study.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: No secondary data are associated with this research. For primary data sources, further inquiries can be directed to the corresponding author.

Acknowledgments: Acknowledgement for the MaaS development consulting support from Key Laboratory of Advanced Public Transportation Science, China Academy of Transportation Sciences, and Automotive Industry Research Center, North China University of Technology.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

MaaS	Mobility as a Service
MNL	Multinomial Logit model
MRS	Marginal Rate of Substitution analysis
TAZ	Traffic Analysis Zone
SP	Stated Preference survey
PAYG	Pay-as-you-go model of MaaS
IIA	Independence of Irrelevant Alternatives assumption
EU	European Union
QR	Quick response codes

References

1. People's Government of China. Boosting Green Transformation and Upgrading. 2026. Available online: https://www.gov.cn/zhengce/202606/content_7072744.htm (accessed on 7 July 2026).
2. Heinen, E.; Mattioli, G. Multimodality and CO2 emissions: A relationship moderated by distance. *Transp. Res. Transp. Environ.* **2019**, *75*, 179–196. [CrossRef]
3. Matyas, M.; Kamargianni, M. Investigating heterogeneity in preferences for Mobility-as-a-Service plans through a latent class choice model. *Travel Behav. Soc.* **2021**, *23*, 143–156. [CrossRef]
4. Alyavina, E.; Nikitas, A.; Njoya, E.T. Mobility as a service (MaaS): A thematic map of challenges and opportunities. *Res. Transp. Bus. Manag.* **2022**, *43*, 100783. [CrossRef]
5. Matowicki, M.; Pecherkova, P.; Amorim, M.; Kern, M.; Motzer, N.; Pribyl, O. Complementing or competing with public transit? Evaluating the parameter sensitivity of potential Mobility-as-a-Service (MaaS) urban users in Germany, the Czech Republic, Poland, and the United Kingdom with a mixed choice model. *Transportation* **2024**, *53*, 399–432. [CrossRef]
6. Dadashzadeh, N.; Sucu, S.; Pangbourne, K.; Ouelhadj, D. Socially Sustainable Mobility as a Service (MaaS): A practical MCDM framework to evaluate accessibility and inclusivity with application. *Cities* **2024**, *154*, 105360. [CrossRef]
7. Vancaemelbecke, C.; Prakash, R.; Lemerrier, C.; Caroux, L. A systematic review of mobility-as-a-service (MaaS): User profiles, app features, persuasive design and user interactions with MaaS. *Transp. Res. Part F Psychol. Behav.* **2026**, *122*, 103746. [CrossRef]
8. Li, R. *Introduction to Mobility as a Service (MaaS)*, 1st ed.; China Communications Press: Beijing, China, 2020.
9. Sochor, J.; Karlsson, I.M.; Strömberg, H. Trying out mobility as a service: Experiences from a field trial and implications for understanding demand. *Transp. Res. Rec.* **2016**, *2542*, 57–64. [CrossRef]
10. Strömberg, H.; Karlsson, I.M.; Sochor, J. Inviting travellers to the smorgasbord of sustainable urban transport: Evidence from a MaaS field trial. *Transportation* **2018**, *45*, 1655–1670. [CrossRef]
11. Ho, C.Q.; Hensher, D.A.; Reck, D.J.; Lorimer, S.; Lu, I. MaaS bundle design and implementation: Lessons from the Sydney MaaS trial. *Transp. Res. Part A Policy Pract.* **2021**, *149*, 339–376. [CrossRef]
12. César, N.; Antoniou, C. The Mobility as a Service Potential Index (MaaSPI): Assessing the conditions for MaaS across countries based on public sources. *Res. Transp. Bus. Manag.* **2025**, *60*, 101360. [CrossRef]
13. Liu, J.; Jian, S.; Wu, C.; Dixit, V. Risky choice and diminishing sensitivity in MaaS context: A nonlinear logit analysis of traveler behavior. *Transp. Res. Part C Emerg. Technol.* **2024**, *162*, 104603. [CrossRef]
14. Sochor, J.; Arby, H.; Karlsson, I.M.; Sarasini, S. A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. *Res. Transp. Bus. Manag.* **2018**, *27*, 3–14. [CrossRef]
15. Smith, G.; Hensher, D.A. Towards a framework for mobility-as-a-service policies. *Transp. Policy* **2020**, *89*, 54–65. [CrossRef]
16. Kriswardhana, W.; Eszterga'r-Kiss, D. Preferences for MaaS bundles: Insights from various choice models. *J. Urban Mobil.* **2026**, *9*, 100191. [CrossRef]
17. Bushell, J.; Merkert, R.; Beck, M.J. Consumer preferences for operator collaboration in intra-and intercity transport ecosystems: Institutionalising platforms to facilitate MaaS 2.0. *Transp. Res. Part A Policy Pract.* **2022**, *160*, 160–178. [CrossRef]
18. The People's Government of Beijing Municipality. How has Beijing MaaS Promoted Green Transport Development in the 14th Five-Year Plan Period? 2025. Available online: https://www.beijing.gov.cn/ywdt/zwtz/sww/fbh/mlbj/202510/t20251026_4240048.html (accessed on 7 July 2026).
19. Tomaino, G.; Teow, J.; Carmon, Z.; Lee, L.; Ben-Akiva, M.; Chen, C.; Leong, W.Y.; Li, S.; Yang, N.; Zhao, J. Mobility as a service (MaaS): The importance of transportation psychology. *Mark. Lett.* **2020**, *31*, 419–428. [CrossRef]
20. Schikofsky, J.; Dannewald, T.; Kowald, M. Exploring motivational mechanisms behind the intention to adopt Mobility as a Service (MaaS): Insights from Germany. *Transp. Res. Part A Policy Pract.* **2020**, *131*, 296–312. [CrossRef]

21. Lopez-carreiro, I.; Monzon, A.; Lopez-lambas, M.E. Comparison of the willingness to adopt MaaS in Madrid (Spain) and Randstad (The Netherlands) metropolitan areas. *Transp. Res. Part A* **2021**, *152*, 275–294. [\[CrossRef\]](#)
22. Zijlstra, T.; Durand, A.; Hoogendoorn-Lanser, S.; Harms, L. Early adopters of mobility-as-a-service in the Netherlands. *Transp. Policy* **2020**, *97*, 197–209. [\[CrossRef\]](#)
23. Ho, C.Q.; Hensher, D.A.; Mulley, C.; Wong, Y.Z. Potential uptake and willingness to pay for Mobility as a Service (MaaS): A stated choice study. *Transp. Res. A Policy Pract.* **2018**, *117*, 302–318. [\[CrossRef\]](#)
24. Alonso-González, M.J.; Hoogendoorn-Lanser, S.; van Oort, N.; Cats, O.; Hoogendoorn, S. Drivers and barriers in adopting Mobility as a Service (MaaS)—A latent class cluster analysis of attitudes. *Transp. Res. Part A Policy Pract.* **2020**, *132*, 378–401. [\[CrossRef\]](#)
25. Suárez, S.; Macedo, E.; Ciccarelli, G.; Bandeira, J.M. User feedback assessment of region-focused mobility-as-a-service bundles. *Multimodal Transp.* **2025**, *4*, 100204. [\[CrossRef\]](#)
26. Liljamo, T.; Liimatainen, H.; Pöllänen, M.; Utriainen, R. People's current mobility costs and willingness to pay for Mobility as a service offerings. *Transp. Res. Part A* **2020**, *136*, 99–119. [\[CrossRef\]](#)
27. Vij, A.; Ryan, S.; Sampson, S.; Harris, S. Consumer preferences for mobility-as-a-service (MaaS) in Australia. *Transp. Res. Part C* **2020**, *117*, 102699. [\[CrossRef\]](#)
28. Wang, C.; Wang, D.; Zhu, W.; Song, S. Research progress of discrete choice models. *Prog. Geogr.* **2015**, *34*, 1275–1287.
29. Theofilatos, E.A. Tram or Bus? A Stated-Preference Analysis of Road User Mode Choice in Larissa, Greece. *Systems* **2026**, *14*, 446. [\[CrossRef\]](#)
30. González, R.M.; Marrero, Á.S.; Marrero, G.A. How the values of travel time change when a panel data around a new tram im-plementation is used. *Eur. J. Transp. Infrastruct. Res.* **2016**, *16*, 554–572. [\[CrossRef\]](#)
31. Ye, F.; Lord, D. Comparing three commonly used crash severity models on sample size requirements: Multinomial logit, ordered probit and mixed logit models. *Anal. Methods Accid. Res.* **2014**, *1*, 72–85. [\[CrossRef\]](#)
32. Li, J.; Yang, G.; Ding, Y.; Liu, J. Impacts of a new rail transit line on travel mode choice. *J. Transp. Syst. Eng. Inf. Technol.* **2022**, *22*, 135–140+153.
33. Shanghai MaaS Public Mobility Annual Report. 2022. Available online: https://www.thepaper.cn/newsDetail_forward_23491123 (accessed on 15 June 2023).
34. Lu, M.; Zheng, L. Traffic big data based subway and taxi connection travel planning. *Comput. Eng. Appl.* **2018**, *54*, 262–270.
35. Matyas, M.; Kamargianni, M. The potential of mobility as a service bundles as a mobility management tool. *Transportation* **2019**, *46*, 1951–1968. [\[CrossRef\]](#)
36. Zhao, W.; Cui, X.; Yu, B. The spatial planning strategy of ride-hailing connections for rail transit sites from the perspective of humanized travel: Case study in Chengdu Xipu metro station. *Huazhong Archit.* **2020**, *38*, 75–80.
37. Ao, C. Research on the Choice of Residents' Travel Modes in Urban Transportation Corridor in Different Weather Conditions. Master's Thesis, Chongqing Jiaotong University, Chongqing, China, 2021.
38. Chen, C.F.; Chen, Y.X. Investigating the effects of platform and mobility on mobility as a service (MaaS) users' service experience and behavioral intention: Empirical evidence from MeNGo, Kaohsiung. *Transportation* **2022**, *50*, 2299–2318. [\[CrossRef\]](#)
39. Wright, S.; Nelson, J.D.; Cottrill, C.D. MaaS for the suburban market: Incorporating carpooling in the mix. *Transp. Res. Part A* **2020**, *131*, 206–218. [\[CrossRef\]](#)
40. Yu, Y. Analysis of connection characteristics between online car-hailing and metro based on multi-source data. *Mod. Transp. Technol.* **2023**, *20*, 64–70.
41. Cho, S.H.; Shin, D.H. Estimation of Route Choice Behaviors of Bike-Sharing Users as First-and Last-mile Trips for Introduction of Mobility-as-a-Service (MaaS). *J. Civ. Eng.* **2022**, *26*, 3102–3113. [\[CrossRef\]](#)
42. Babar, Y.; Burtch, G. Examining the heterogeneous impact of ride-hailing services on public transit use. *Inf. Syst. Res.* **2020**, *31*, 820–834. [\[CrossRef\]](#)
43. Qin, Y. Commuting Mode Choice Under New Supply-Demand Conditions: A Behavioral Study. In Proceedings of the 2021/2022 China Urban Transportation Planning Annual Conference, Shanghai, China, 17–18 November 2022; pp. 1166–1178.
44. Huang, S.; Chen, H.; Zhong, H.; Chen, L.; Tian, X.; Liu, X. Feature identification and fuel-saving estimation for multimodal travel of online car-hailing ride-sharing and subway. *Urban Transp. China* **2023**, *21*, 21–30.
45. Lamberton, C.P.; Rose, R.L. When is ours better than mine? A framework for understanding and altering participation in commercial sharing systems. *J. Mark.* **2012**, *76*, 109–125. [\[CrossRef\]](#)
46. Ren, X. Exploration and thinking of the MaaS model for the last-mile travel in industrial parks. *Traffic Transp.* **2024**, *40*, 88–93.
47. Harms, L.; Durand, A.; Hoogendoorn-Lanser, S. *Exploring Mobility-as-a-Service: Insight from Literature and Focus Group Meetings*; Netherlands Institute for Transport Policy Analysis (KiM): Den Haag, The Netherlands, 2018.
48. Wang, J.; Shi, R.; Zhou, Y.; Zhang, P.; Wu, A. Study of transport service capability of urban tourist attraction with MaaS. *J. Transp. Eng.* **2021**, *21*, 25–32.
49. Zhang, X. Reflection on Shen Zhen bus development mode and exploration of MaaS. *Commun. Shipp.* **2019**, *6*, 7.

50. Pan, H.; Du, L. *Multi-Modal Transport System and Inter Mobility*; Tongji University Press: Shanghai, China, 2003.
51. Ge, H. Research on the Method of Urban Public Bicycle Effectiveness Analysis. Master's Thesis, Southeast University, Nanjing, China, 2017.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.