

Research Article

MaaS Bundling and Acceptance in the Pandemic Era: Evidence from Padua, Italy

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Given the benefits both individuals and collectivity have achieved over the past few years thanks to Mobility-as-Service (MaaS) systems, various studies were conducted to predict the level of acceptance of MaaS bundles from different territorial scales and in different countries. Results obtained are in some cases contradictory. Literature is lacking in the study of small-to-medium-sized urban contexts and in the effects of the ongoing COVID-19 pandemic. This paper aims to understand (1) what factors influence respondents' preferences between their usual transportation means and a possible MaaS alternative and (2) what leads a user to prefer one MaaS bundle to another. A logistic regression and a mixed logit model were developed to reach the two aims, respectively. These models were calibrated using questionnaires administered to employees of the Municipality of Padua, a medium-sized city in Italy. Aspects concerning the perception of health safety in relation to the COVID-19 pandemic were included in the analyses. In 37% of the cases, users stated they would be willing to adopt at least one of the proposed MaaS bundles. The results suggest that MaaS solutions can be a useful tool for managing mobility even in medium-sized cities, provided users' biosecurity concerns are addressed by appropriate countermeasures.

1. Introduction

Mobility-as-a-Service (MaaS) seeks to integrate different transportation modes to facilitate seamless intermodal planning, booking, and payment through a single interface. According to one of the earliest definitions available in the literature [1], MaaS is a system in which mobility operators provide to customers a comprehensive range of mobility services. In fact, it can be regarded as a set of transportation services that different operators provide, typically bundled in packages and available within a single integrated platform [2], with the aim of providing more efficient mobility solutions [3, 4]. MaaS could potentially reduce the ownership and costs of private vehicles and promote less resource-intensive modes of transportation, such as public transportation or shared services [5–7]. In this context, the

present work focuses on understanding which factors influence bundle choice and its acceptance in a medium-sized city; aspects related to the COVID-19 pandemic were also considered in the analyses. As shown in Section 2, these aspects are still scarcely explored; in this sense, the present study can significantly contribute to the growing body of literature on MaaS bundling.

As the concept of MaaS is gaining increasing interest in both industry and research, there is a large body of literature that analyzes both its capabilities and its possible barriers/risks [8]. In the last few years, the use of intelligent transportation systems has been growing rapidly in modern day cities to promote safer and more organized mobility [9]. MaaS could be applied in the context of smart road management and could be functional toward implementing autonomous vehicles in transportation systems [10].

Typically, in a MaaS scheme, users can pay for each trip (pay-as-you-go, PAYG) or subscribe to mobility bundles/packages. The concept of bundles is receiving increasing attention (see Section 2), and many stated preferences (SP) surveys investigated the effect of sociodemographic characteristics and the transportation modes included in the bundle on users' preferences and their willingness to pay. In many cases, these SP survey-based approaches were the only viable means of investigating the problem because only a limited number of real-world pilot studies have been completed (e.g., the UbiGo field trial in Gothenburg [11] or the Sydney MaaS trial [12–14]), and only few commercial products are available (e.g., Whim). Although, alternative simulative agent-based approaches have been proposed [15, 16].

Recently, Reck et al. [17] reviewed the literature on MaaS bundles, highlighting that there is a lack of research on how to build MaaS bundles and that fundamental differences in survey design limit comparative learning from previous studies, which may explain some contradictory results. Mixed results may also be due to differences in the characteristics of the samples surveyed. Regarding this, Section 2 highlights that virtually all previous SP studies on MaaS bundling gathered data from large urban areas or even entire nations; conversely, there is a lack of studies investigating the potential of MaaS bundling in the context of small/medium-sized cities.

In the last few years, the COVID-19 pandemic has produced profound changes in everyday life worldwide, particularly in the way people move, with changes in travel frequency and preferred transportation modes [18–20]. There has been much speculation on what mobility could look like after COVID-19, with one possible scenario being a return to the situation before the virus outbreak and another being a “new normal” that the pandemic experience has strongly influenced [21]. In this context, MaaS faces both opportunities and challenges [22]: on the one hand, an impulse toward the digital transition and sustainable transportation modes [23]; on the other hand, a reduction in travel demand and the use of public transportation [24].

Here, an SP survey was carried out during fall 2020 in Padua (Italy), a city with about 200,000 inhabitants within its administrative limits and about 400,000 when considering the wider urban area. The main objective of this paper is to contribute to the body of knowledge on MaaS bundles, as several studies have previously requested, including [17] and to investigate its potential within a medium-sized Italian city. In particular, the objectives are to understand (1) what factors influence respondents' preferences between their usual transportation means and a possible MaaS alternative and (2) what leads a user to prefer one MaaS bundle to another.

Furthermore, the survey was administered within the COVID-19 pandemic context, and the results of the present study provide significant insights on how the pandemic may affect MaaS bundling and its acceptance.

2. SP Studies on MaaS Bundling

In the scientific literature on MaaS, one of the first studies investigating the concept of bundles as a mobility management tool was that of Matyas and Kamargianni [25],

using an SP survey specifically designed for the task [26, 27]. Their study area was Greater London and involved people over 18 years with a sample that was partially representative of the whole population. Respondents had to choose between three bundles, which could include a combination of subscriptions to public transportation, bike sharing, and taxi and car sharing; subsequently, they were asked about their likelihood to subscribe to their chosen plan. Methodologically, the authors applied two mixed multinomial logit (MNL) models to analyze their results, the first one including data from the whole sample, and the second one including only the responses of those who were likely to subscribe to the chosen bundle. The results of the models were closely aligned, and they highlighted public transportation's role as the backbone of MaaS. A similar SP experiment was carried out in the Netherlands to investigate the potential role of MaaS bundles as a tool to influence the choice of the commute mode [28]. The study focused exclusively on employees who commute to work using private/leased car and public transportation. Mobility packages included different combinations of subscription levels for trains, public transportation, car sharing, and e-bike sharing, and also the use of private cars, with an increased parking tariff. The result of their mixed MNL model suggested that the presence of trains, car sharing, price, and the parking tariff were all influential factors for the choice of employees' mode, showing the advantages of combining both incentives and deterrents in transportation demand management strategies.

Concurrently, Ho et al. [29] adopted a face-to-face stated choice study to investigate the potential uptake and willingness to pay for MaaS. Their study involved 252 Sydney-based people who were asked to choose between their current travel pattern and other MaaS bundles generated based on previous responses. The MaaS alternatives included both bundles and PAYG plans. Their results indicated that nearly half of the survey respondents would accept the MaaS solution and that the levels of potential uptake varied considerably in each segment of the population, with casual car users being the most likely adopters and car nonusers being the least. Furthermore, the willingness to pay was much lower compared to the current daily limit (according to a subsequent case study located in Australia [30]), suggesting a careful segmentation of the market and the need for cross-subsidy strategies. Kim et al. [31], who investigated the potential of the MaaS package in Seoul using a web-based interview, followed a similar approach and design. In their study, the binary choice task between the current travel pattern and a proposed mobility package was repeated five times. A latent class model was developed and showed that latent classes corresponded to public transportation-oriented and balanced-mode people, with different influencing factors. Their study's results emphasized the importance of considering the characteristics of users and building environment in planning MaaS systems.

Guidon et al. [32] adopted a survey design in which Zurich citizens were asked to consider MaaS bundles and standalone subscriptions to transportation services. Many transportation modes were found to be significantly more

attractive within bundles, with the exception of taxi and bike/e-bike sharing. For this reason, the authors concluded that mobility providers should not include all transportation modes in composing the bundles.

Another survey-based study investigated MaaS bundles in Greater Manchester [33]. Unlike previously discussed works, respondents had to “build” their ideal MaaS package from a pool of mobility services, including bike sharing, car sharing, taxi, and public transportation (an approach also adopted in another SP choice survey administered in the Netherlands [34]). The price was then calculated based on the chosen features. Consistent with previous studies [29], MaaS could particularly benefit casual car users, while frequent bus users prefer MaaS bundles that only include public transportation. They also discussed the importance of sociodemographic characteristics and the willingness to pay. Within the same research project, another paper addressed the question of preference heterogeneity and developed a latent class choice model [35]. From this, three latent classes emerged, each with a different MaaS package preference and individual characteristics, with current travel habits, gender, age, education, and income all playing significant roles.

According to this literature overview on MaaS bundles, several studies have been conducted over the last few years. However, it is relevant to stress that even if they all shared the same broad objective (i.e., to study the demand for MaaS bundles), their conclusions strongly depend on how the surveys were designed. In particular, it is possible to identify four types of discrete choice designs:

- (1) Respondents choose among different MaaS bundles (e.g., [25])
- (2) Respondents choose between the current travel pattern and one or more MaaS bundles (e.g., [29])
- (3) Respondents choose between MaaS bundles and standalone subscriptions (e.g., [32])
- (4) Respondents build their own MaaS bundle (e.g., [33])

This led to somewhat contradictory results in certain cases (e.g., Guidon et al. [32] found a positive willingness to pay for a MaaS bundle with car sharing, whereas Matyas and Kamargianni [27] found negative preferences for MaaS bundles that included this service), and several papers (e.g., [25, 36]) highlighted the need for further studies to confirm/extend their findings. Furthermore, all of the above-discussed works dealt with case studies that considered entire nations or large urban areas. The potential of MaaS bundling in small/medium-sized cities is still relatively unexplored. Finally, only a few published papers discussed SP surveys on MaaS bundling conducted during the COVID-19 pandemic [37], and virtually none discussed its implications on users’ preferences.

Given this background in the literature, the present work contributes to exploring MaaS bundling and its acceptance within the specific context of a medium-sized city, including COVID-19 factors and their implications. The SP design adopted here was inspired by [25] and can be regarded as a combination of designs 1 and 2, considering that

respondents were asked to choose both between different bundles and between the selected bundle and their current travel plan (more details in Section 3).

3. Materials and Methods

To investigate preferences in MaaS bundling and to analyze factors that could affect its adoption, an online questionnaire was administered between October 2020 and January 2021 to employees of the Municipality of Padua. Note that Padua is an Italian densely populated medium-sized city; currently, around 200,000 people live within its administrative limits and 400,000 within the wider urban area, with a density of about 2,300 inhabitants per square kilometer.

Considering the information needed to apply a stratified random sampling approach was not available, all people working in the municipality were asked to participate in the survey (including office workers, technicians, police officers, and teachers). In particular, while workplaces of potential respondents were within the municipality but not in the same building, individuals could live in any area of the Veneto region.

Specifically, 142 out of 255 respondents declared to live within the city limits, 230 within its province, and all of them within the Veneto region. The city offers several transportation services: urban bus, tram, bike sharing, e-bike sharing, e-scooter sharing, taxi, and car sharing. Padua is also connected to external areas through suburban bus and train services; in addition, there are two Park & Ride areas (one in the north and one in the south) at the city’s entrance.

The survey was divided into four sections. In the part related to revealed preferences (RP), information was collected regarding travel habits, such as the number of weekly trips, frequency of use of different vehicles, and average travel time for working trips. Respondents were asked to select the most frequently used mode of commute in the pre-pandemic phase, among the following 14 modes: walking, private bike, bike sharing, e-scooter sharing, motorbike, car as a driver alone, car as a driver with passengers, car as a passenger, carpooling, car sharing, taxi, urban public transportation (bus or tram), suburban bus, and train.

In the second part, subjects were asked about aspects related to the COVID-19 pandemic, such as the perceived level of health risk with respect to the current spread of the virus, the perceived level of safety from the health point of view for different travel modes, individual concern about contagion, and the importance of specific measures to contain the spread of the virus onboard vehicles and at public transit stops and stations.

In the third part, panel-structured SP experiments were administered. In particular, each respondent faced choice tasks in which they had to choose between two MaaS bundles [25]. Each bundle’s attributes were defined as a mix of existing mobility services in Padua. The cost of each mobility option in the bundles was derived from what real operators provide in the area. In this way, realistic SP experiments were obtained. Furthermore, following the approach that [25] proposed, not to increase the response burden, neither the status quo option nor the PAYG option were included

TABLE 1: MaaS package components.

Attributes	Levels	Standard cost (€/month)
Bike sharing	Unlimited, not included	10, 0
E-scooter sharing	Unlimited, not included	25, 0
Car sharing	5 hours included, pay-as-you-go, not included	50, 1, 0
Local public transport	Unlimited, unlimited rides for 10 days, not included	39, 20, 0
Train/suburban bus	Unlimited, not included	As stated in RP, 0
Park & Ride	Unlimited, not included	10, 0
Night bus	10 rides, 5 rides, not included	15, 7.5, 0
Cost	0.8, 1, 1.2* standard cost	

among the alternatives. Five different experiments were defined, with different attributes of the alternatives, consistently with information from the RP part of the survey (e.g., main transportation mode used and driving license). A D-optimal design procedure was implemented, generating 16 choice scenarios. These scenarios were grouped in blocks so that each unique respondent had to answer four choice tasks. After each SP experiment, respondents had to indicate whether they were willing to adopt the chosen MaaS package, as opposed to their current travel mode. This twofold question structure allowed investigating the MaaS bundling as well as the potential adoption of the service. Table 1 shows the potential components of the proposed MaaS bundles as well as their subscription levels and associated costs. Each of the proposed bundles was defined monthly.

Socioeconomic information was collected in the last part of the survey, both at the household level (members, number of cars, bikes and motorbikes, and total income) and at the individual level (age, gender, postcode of residence, subscription to public transportation, car sharing, and bike sharing).

Data collected were used to calibrate two different models. First, a mixed logit model was implemented to understand factors that influence the choice of one bundle rather than another. Secondly, logistic regression was developed to analyze factors influencing the potential adoption of a proposed MaaS package. Methodologically, with respect to the four discrete choice designs identified in the literature review in Section 2, the present approach can be considered as a combination of designs 1 and 2 because respondents were first asked to choose among different bundles (leading to the MaaS bundle choice model, Section 3.1) and later between the selected bundle and their current travel pattern (leading to the MaaS adoption model, Section 3.2). In this way, a comprehensive analysis was performed, with the aim to analyze not only the choice of a specific MaaS bundle but also the future use of the service.

3.1. MaaS Bundle Choice Model. Mixed logit is a discrete choice model that overcomes some of the standard logit model's limitations by considering random variations in taste between selectors, unrestricted substitution patterns across choices, and correlation in not observed factors over time [38]. In this paper, a mixed logit model was calibrated using answers to SP experiments, where respondents had to

choose between the two MaaS bundles. The model allowed accounting for the survey's panel structure. The model was calibrated using Biogeme software [39].

Table 2 shows the list of exogenous variables used for model specification.

3.2. MaaS Adoption Model. Logistic regression is a generalized linear regression model used when the dependent variable is dichotomic. In this paper, the model was used to investigate the probability of adopting MaaS, considering the characteristics of both the bundles and the respondents.

Significant variables were selected manually and by applying an automated stepwise procedure. The model was built with R statistical software [40]. Table 3 shows the list of exogenous variables used in the model's final version. Note that the variables related to the COVID-19 pandemic were included in the model specification; in this way, potential effects of the pandemic on future MaaS diffusion were investigated.

4. Results and Discussion

There were 255 complete questionnaires. There are 1,650 employees of Padua's municipality, which corresponds to a sampling rate of about 16%; the sample size was considered appropriate for a margin of error of 10% at 95% confidence level [41].

Table 4 provides a summary of the respondents' socioeconomic characteristics.

Table 5 shows the main travel means subjects used to reach their workplace; driving own car was the most common travel mode, followed by private bikes. Indeed, most respondents (56%) live in Padua's municipality and need to cover relatively short distances to commute. A quarter of the interviewees adopted public transportation modes (bus and train). At the time of survey administration, shared mobility services (bike, e-scooter, and car) seem not to be appreciated (1% of the sample selected bike sharing).

4.1. MaaS Bundle Choice-Model Estimation. Results from the calibration phase of the mixed logit model that predicts the choice between two MaaS bundles are reported in Table 6. In the model's final version, three random parameters were adopted. Constants were included with a normal distribution, as were the cost of packages; conversely, the variable related to the presence of e-scooter sharing service in the

TABLE 2: Description of exogenous variables from the MaaS bundle choice model.

Name	Description	Type	Level
HH_CAR	Number of household cars	Metric	Household
HH_MOTO	Number of household motorbikes	Metric	Household
INCOME	Household income (1000€)	Metric	Household
F_CAR	Frequency of private car use (times/week)	Metric	Individual
PD	Living inside Padua municipality	Metric	Individual
BS	Bike sharing service (unlimited) in the MaaS package	Dummy	MaaS
COST	Cost of the MaaS package	Metric	MaaS
CS_HOUR	Car sharing service (5 hours) in the MaaS package	Dummy	MaaS
CS_RATE	Car sharing service (pay-as-you-go) in the MaaS package	Dummy	MaaS
NB	Night bus service in the MaaS package	Metric	MaaS
PARK	Park & Ride service (unlimited) in the MaaS package	Dummy	MaaS
SC	E-scooter sharing service (unlimited) in the MaaS package	Dummy	MaaS
SUB	Suburban (train/bus) public service (unlimited) in MaaS package	Dummy	MaaS
TPL	Urban public transportation service (unlimited) in the MaaS package	Dummy	MaaS
TPL_10DAYS	Urban public transportation service (unlimited for 10 days) in the MaaS package	Dummy	MaaS
RP_ACTIVE	Used active mobility (by foot or bike) in the past to commute	Dummy	Trip
RP_CAR	Used car (driver or passenger) in the past to commute	Dummy	Trip
RP_MOTO	Used motorbike in the past to commute	Dummy	Trip
RP_PT	Used public transportation in the past to commute	Dummy	Trip

TABLE 3: Description of exogenous variables used in the MaaS adoption model.

Name	Description	Type	Level
HH_CAR	Number of household cars	Metric	Household
INCOME	Household income (1000€)	Metric	Household
AGE	Age	Metric	Individual
F_BUS	Frequency of urban bus use (times/week)	Metric	Individual
F_PB	Frequency of private bike use (times/week)	Metric	Individual
F_TRAIN	Frequency of train use (times/week)	Metric	Individual
GENDER_F	Female	Dummy	Individual
MEAS_E_4	Importance of automatic access control via web, phone, or app booking system for public transportation to reduce the risk of infection (important)	Dummy	Individual
MEAS_E_5	Importance of automatic access control via web, phone, or app booking system for public transportation to reduce the risk of infection (very important)	Dummy	Individual
MEAS_F_4	Importance of daily sanitization of vehicles and stations to reduce the risk of infection (important)	Dummy	Individual
MEAS_H_5	Importance of body temperature checks with thermal scanners at station entrance to reduce the risk of infection (very important)	Dummy	Individual
MEAS_L_2	Importance of walk a few more minutes to reach less crowded stations/stops to reduce the risk of infection (not important)	Dummy	Individual
MEAS_L_5	Importance of walk a few more minutes to reach less crowded stations/stops to reduce the risk of infection (very important)	Dummy	Individual
PD	Living inside Padua municipality	Dummy	Individual
SAFE_BUS_1	Perceived level of travelling health risk on transportation means (not at all safe)	Dummy	Individual
SAFE_BUS_2	Perceived level of travelling health risk on transportation means (not safe)	Dummy	Individual
COST	Cost of the MaaS package	Metric	MaaS
CS_HOUR	Car sharing service (5 hours) in the MaaS package	Dummy	MaaS
CS_RATE	Car sharing service (pay-as-you-go) in the MaaS package	Dummy	MaaS
NB	Night bus service in MaaS package	Metric	MaaS
PARK	Park & Ride service in the MaaS package	Dummy	MaaS
SC	E-scooter sharing service (unlimited) in the MaaS package	Metric	MaaS
TPL	Urban public transportation service (unlimited) in the MaaS package	Dummy	MaaS
TPL_10DAYS	Urban public transportation service (unlimited for 10 days) in the MaaS package	Dummy	MaaS
RP_BUS	Used urban bus in the past for the commuting trip	Dummy	Trip
RP_DRIVEPASS	Used car (as driver with passengers) in the past for the commuting trip	Dummy	Trip
RP_MOTO	Used motorbike in the past for the commuting trip	Dummy	Trip
TT	Travel time for the commuting trip (min)	Metric	Trip

TABLE 4: Socioeconomic information of the sample.

	N	%
Totals	255	100
Household members		
1	53	21
2	56	22
3	64	25
4	65	25
More than 4	17	7
Licensed drivers		
0	5	2
1	68	27
2	115	45
3	51	20
More than 3	16	6
Available cars		
0	6	2
1	109	43
2	118	46
3	20	8
More than 3	2	1
Available bikes		
0	10	4
1	32	13
2	70	27
3	55	22
More than 3	88	35
Available motorbikes		
0	165	65
1	75	29
2	13	5
3	2	1
More than 3	0	0
Household income (€/month)		
Less than 1000	6	2
1000–1500	70	27
1500–2000	31	12
2000–3000	85	33
3000–4000	46	18
4000–6000	11	4
6000–10000	2	1
More than 10,000	4	2
Gender		
Female	168	66
Male	87	34
Age		
18–24	0	0
25–29	1	0
30–34	5	2
35–44	40	16
45–54	89	35
55–64	116	45
More than 65	4	2
Bus pass		
Yes	39	15
No	216	85
Train pass		
Yes	22	9
No	233	91
Bike sharing pass		

TABLE 4: Continued.

	N	%
Yes	2	1
No	253	99
Living in Padua		
Yes	142	56
No	113	44

TABLE 5: Modal share of sample for commute.

	N	%
Total	255	100
Walking	10	4
E-scooter sharing	0	0
Private bike	59	23
Bike sharing	2	1
Motorbike	25	10
Car (alone)	86	34
Car (driver, with passengers)	7	3
Car (as passenger)	5	2
Car sharing	0	0
Bus	27	11
Suburban bus	12	5
Train	22	9

bundle followed a uniform distribution. Moreover, 1,000 Halton intelligent draws were used.

The bundle's cost had a negative effect, as expected (B_COST). MaaS packages with unlimited bike sharing (B_BS), car sharing with PAYG option (B_CS_RATE), and unlimited urban public transportation (B_TPL) were likely to be chosen. On the contrary, the presence of a 10-day urban public transportation pass (B_TPL_10DAYS) had a negative effect on users' choice of the bundle; however, this effect was reversed for people living in Padua (B_PDXTPL_10DAYS).

Mobility habits were found to play a significant role on the bundle choice. Those travelling to work using a private car appreciated Park & Ride (B_RP_CARXPARK). Moreover, the coefficient of the variable representing the interaction between the private car frequency and the presence of 5-hour car sharing was negative, indicating that this service could not foster substituting private vehicles (B_F_CARXCS_HOUR). Surprisingly, the car did not reduce the likelihood of choosing MaaS bundles with public transportation. In particular, commuters travelling via car appreciated bundles containing urban transit more than others did (B_RP_CARXTPL), and the number of cars available in the family positively affected the adoption of bundles with a 10-day public transportation pass (B_HH_CARXTPL_10DAYS); this aspect will certainly need to be verified with future studies, but it could be due to the proposed service's flexibility. However, the coefficient of the variable indicating the interaction between the night bus service and household cars was negative (B_HH_CARXNB); this was an expected result because people belonging to households with a large number of

TABLE 6: MaaS bundle choice-estimated parameters and model statistics.

Variable name	Coefficient	SE	z value	p value
ASC_Ast.dev.	1.020	7.000	7.140	<0.001***
ASC_B mean	0.350	0.193	1.810	0.070†
ASC_Bst.dev.	0.983	0.142	6.900	<0.001***
B_BS	0.406	0.146	2.780	0.005**
B_COSTmean	-0.014	0.004	-3.420	<0.001***
B_COSTst.dev.	-0.021	0.006	-3.620	<0.001***
B_CS_RATE	0.305	0.157	1.950	0.051*
B_F_CARxCS_HOUR	-0.202	0.069	-2.940	0.003**
B_HH_CARxNB	-0.046	0.012	-3.860	<0.001***
B_HH_CARxTPL_10DAYS	0.682	0.185	3.680	<0.001***
B_HH_MOTOxSC	-0.535	0.239	-2.240	0.025*
B_INCOMExSC	0.118	0.075	1.570	0.116
B_PDxCOST	-0.006	0.003	-2.110	0.036*
B_PDxTPL_10DAYS	0.918	0.335	2.740	0.006**
B_RP_ACTIVExSC	1.460	0.322	4.530	<0.001***
B_RP_CARxPARK	1.270	0.278	4.560	<0.001***
B_RP_CARxTPL	1.430	0.304	4.710	<0.001***
B_RP_MOTOxCS_RATE	1.410	0.477	2.950	0.003**
B_RP_PTxBUS	3.180	0.920	3.460	0.001**
B_SCmean	-1.680	0.524	-3.200	0.001**
B_SCst.dev.	2.640	0.915	2.880	0.004**
B_TPL	0.656	0.263	2.490	0.013*
B_TPL_10DAYS	-0.323	0.223	-1.450	0.147
<i>Significance codes: ***p value <0.001; **p value <0.01; *p value <0.05; †p value <0.10</i>				
Statistics				
N. of observation		1,020.00		
N. of draws		1,000.00		
Null log likelihood		-1,072.59		
Final log likelihood		-563.99		
Likelihood ratio test		1,017.20		
Rho-square-bar		0.45		
Akaike criterion (AIC)		1,173.99		

vehicles are likely to use one of them, instead of public transportation, during the night.

As expected, commuters using public transportation showed a strong propensity toward MaaS packages containing suburban transportation services (B_RP_PTxBUS). In addition, people adopting active modes seemed to prefer bundles with the e-scooter sharing service (B_RP_ACTIVExSC).

4.2. MaaS Adoption-Model Estimation. The calibration of the logistic regression parameters and model statistics are reported in Table 7. The model predicts the probability of adopting the MaaS plan chosen in the previous SP experiment. Concerning general bundle composition, results showed that the car-sharing service (CS_HOUR, CS_RATE) prompted respondents to reject the MaaS (according to the negative coefficient reported in [25]). Users who took more time to travel from home to work declared they were more willing to adopt the MaaS system (TT). People who lived in Padua, on the other hand, were less interested in the service (PD), except for bundles that included Park & Ride (PDxPARK) and the e-scooter sharing service (PDxSC). Women were less attracted to MaaS in general (GENDER_F), but they seemed to appreciate bundles containing unlimited urban transportation services (GENDER_FxTPL). This is somewhat consistent with

recent studies reporting that women do not well receive shared mobility regarding safety, reliability, and user-friendliness, even though women are known to use public transportation more than men do [42]. This also highlights the need for additional studies on the gender gap in the transportation sector [43]. As the weekly use of city bus, private bike, or train increased, the attractiveness of MaaS decreased (F_BUS, F_PB, F_TRAIN). The older respondents appreciated MaaS more (AGE), which opposed what was observed in other studies [34, 44], except for the packages that contained the e-scooter sharing service (AGExSC). Understandably, as income per household increased, there was a greater propensity to accept higher cost bundles (INCOMExCOST), but at the same time, those with greater economic resources did not appreciate the night bus service (INCOMExNB). As the number of cars available to the family increased, the declared propensity for the adoption of MaaS decreased (HH_CAR). Users who used the bus, the car as a passenger or the motorcycle as the main means of commute declared they would be in favor of adopting the proposed MaaS bundles (RP_BUS, RP_DRIVEPASS, RP_MOTO).

Variables related to the COVID-19 pandemic could play a nonnegligible role on MaaS adoption. As previous authors reported [24], biosecurity concerns about public transportation was found to be one of the main affecting factors. Respondents who considered using urban public

TABLE 7: MaaS adoption-estimated parameters and model statistics.

Variable name	Coefficient	Odds	SE	z value	p value
AGE	0.026	1.027	0.014	1.874	0.061†
AGExCS_HOUR	0.062	1.064	0.032	1.920	0.055†
AGExSC	-0.012	0.989	0.005	-2.341	0.019*
CONSTANT	-2.966	0.052	0.908	-3.265	0.001**
CS_HOUR	-3.455	0.032	1.816	-1.903	0.057†
CS_RATE	-0.534	0.586	0.205	-2.608	0.009**
F_BUS	-0.146	0.864	0.088	-1.659	0.097†
F_PB	-0.143	0.867	0.059	-2.439	0.015*
F_TRAIN	-0.195	0.823	0.078	-2.492	0.013*
GENDER_F	-0.666	0.514	0.232	-2.877	0.004**
GENDER_FxTPL	0.894	2.445	0.358	2.495	0.013*
HH_CAR	-0.417	0.659	0.143	-2.905	0.004**
INCOMExCOST	0.001	1.000	<0.001	4.787	<0.001***
INCOMExCS_HOUR	-0.001	1.000	<0.001	-2.061	0.039*
INCOMExNB	-0.001	1.000	<0.001	-2.268	0.001**
MEAS_E_4	1.047	2.849	0.395	2.654	0.008**
MEAS_E_5	1.259	3.521	0.409	3.081	0.002**
MEAS_F_4	1.420	4.138	0.302	4.697	<0.001***
MEAS_H_5	0.541	1.717	0.224	2.409	0.016*
MEAS_L_2	0.972	2.643	0.478	2.035	0.042*
MEAS_L_5	0.581	1.787	0.202	2.875	0.004**
PD	-1.126	0.324	0.293	-3.849	<0.001***
PDxPARK	0.917	2.501	0.349	2.627	0.009**
PDxSC	0.615	1.849	0.363	1.694	0.09†
RP_BUS	0.728	2.071	0.504	1.445	0.149
RP_DRIVEPASS	0.888	2.430	0.515	1.723	0.084†
RP_MOTO	0.842	2.320	0.323	2.609	0.009**
SAFE_BUS_1xTPL	-1.323	0.266	0.331	-4.000	<0.001***
SAFE_BUS_1xTPL_10DAYS	-0.637	0.529	0.259	-2.458	0.014*
SAFE_BUS_2xTPL	-1.152	0.316	0.382	-3.016	0.003**
SAFE_BUS_2xTPL_10DAYS	-0.563	0.570	0.353	-1.597	0.11
TT	0.021	1.022	0.006	3.372	0.001**
<i>Significance codes: ***p value <0.001; **p value <0.01; *p value <0.05; †p value <0.10</i>					
Statistics					
N. of observation			1,200		
Null log likelihood			-507.63		
Final log likelihood			-420.61		
Cragg and Uhler's rho-squared			0.25		

transportation very unsafe or unsafe, from a health point of view, declared that they would be more likely to reject a MaaS scheme containing the urban public transportation option (SAFE_BUS_1XTPL, SAFE_BUS_1xTPL_10DAYS, SAFE_BUS_2xTPL, SAFE_BUS_2xTPL_10GG). Regarding the countermeasures that could be adopted to contain the spread of COVID-19, those who rated as important or very important to control access to public means via the web, telephone, or app booking system declared they were more inclined to adopt proposed MaaS solutions (MEAS_E_4, MEAS_E_5); the same was true for those who believed that daily sanitizing vehicles and stations was important (MEAS_F_4) and for those who considered body temperature checks with thermal scanners at the station entrance as very important (MEAS_H_5). MEAS_L_2 and MEAS_L_5 were both positive, showing that MaaS can be appreciated by those who are unwilling and, similarly, by those who are willing to walk a few more minutes to reach less crowded stations/stops to reduce risks associated with COVID-19.

5. Conclusions

In this research activity, answers from a questionnaire administered to employees of the Municipality of Padua (Italy) were used to understand factors that (1) affect the adoption of MaaS and (2) most influence the choice of a specific package over another. Two models have been built: the first, mixed logit to interpret which MaaS bundle compositions were more attractive than others were; the second model, a logistic regression model to evaluate the factors that affected MaaS adoption replacing the transportation mode currently used. As this is an SP experiment, all the information collected is in hypothetical terms. From a socioeconomic point of view, age and gender had no effect on package composition preferences, but women were less likely to change their habits regarding adopting MaaS; high-income people and people with a large number of cars available in the household were not particularly interested in the services offered.

Users who made very long trips from home to work (regarding time) were more likely to join MaaS, probably because it would represent an inexpensive/cheap solution in any case. People who lived near the workplace and those who were accustomed to riding their bike to get to work were not inclined to choose MaaS solutions (the two groups partially coincided). Furthermore, extending the potential catchment area of MaaS played a significant role in its future adoption; in particular, people living in the city center, although less willing to subscribe, were more likely to accept a bundle with Park & Ride services and e-scooter sharing. From this point of view, the present work contributes to shed light on the MaaS relevance in a typical medium-sized city. In about 20% of the cases (202 out of 1,020 choices), respondents stated they would be willing to change their travel habits by adopting the proposed MaaS bundle. More than 37% of respondents (95 out of 255) indicated they were inclined to accept more than one of the bundles proposed in the four choice exercises. Regarding proposed MaaS configurations, car-sharing services received the least appreciation. Users accustomed to using shared modes were most likely to join MaaS. Lastly, the biosecurity concern of travelling on public transportation could significantly reduce the likelihood to adopt MaaS. This represents a barrier to adopting the service because public transit is usually regarded as the backbone of MaaS. However, the analysis pointed out specific countermeasures, both onboard vehicles and at stations/stops, which could mitigate the negative effects of the COVID-19 pandemic on the future diffusion of MaaS.

In conclusion, the results showed that a good portion of commuters would be willing to adopt MaaS, demonstrating the potential of the latter in improving urban and nonurban mobility. The results obtained can help companies build MaaS bundles that are more attractive for users, thus promoting its adoption. Starting from these considerations, future studies could investigate the attractiveness of packages' components in a similar context, in particular, focusing on packages' prices and exploring different and/or larger samples. The MaaS system can be an excellent tool to improve traveler habits and simultaneously improve environmental and traffic conditions in the network, despite the situation and uncertainties related to the presence of the COVID-19 pandemic. Although the virus implies a general lower propensity to use shared means of transportation, using the right countermeasures could be a correct approach to return to normal modal split levels, and in fact, foster new sustainable mobility services such as MaaS in many cities.

Data Availability

The data used to support the findings of this study are available upon request from the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Conceptualization was conducted by MG, RR, RC, AB, and FO; methodology was carried out by AB and RC; software was performed by AB, RC, and FO; validation was conducted by RC and FO; formal analysis was carried out by AB; investigation was conducted by AB, FO, and RC; data curation was performed by AB, FO, and RC; writing, review, and editing were performed by RC, MG, FO, and AB; supervision was conducted by MG and RR.

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