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Preference Model in the Context of Mobility as a Service: A Pilot Case Study

Antonella Franco [1] and Antonino Vitetta [2,*]

[1] Dipartimento di Ingegneria Civile, dell'Energia, dell'Ambiente e dei Materiali, Università degli Studi Mediterranea di Reggio Calabria, 89122 Reggio Calabria, Italy; franco__antonella@outlook.it
[2] Dipartimento di Ingegneria dell'Informazione, delle Infrastrutture e dell'Energia Sostenibile, Università degli Studi Mediterranea di Reggio Calabria, 89122 Reggio Calabria, Italy
* Correspondence: vitetta@unirc.it

Abstract: In this paper, a pilot study of a pre-test preference model in the context of mobility as a service (MaaS) is defined by following the steps required for transport system engineering: survey, specification, calibration, and validation. The availability of a MaaS preference model is crucial to support decision takers and decision makers before starting planning activities for new, sustainable transport services. In this paper, a pre-test model is proposed for evaluating user preferences. The pre-test model was specified with a Logit random utility model and the parameters were estimated using the maximum likelihood method. To define the preference model, a pilot survey was conducted in the Gioia Tauro area, an extra-urban area in southern Italy. For the pre-test model, a pilot sample of users was considered. In the area, a high percentage of users traveled by an individual transport system; this high percentage was also present in the survey, with 76% traveling by private car. Short- and long-distance scenarios were proposed to users. In the calibrated model, it emerged that bundles were more attractive for long-distance journeys and decreased with the cost of the package. The additional cost in the present scenario influenced the preference for bundle cost. Considering the parking cost in the present scenario (scenario 2), the MaaS preference probability started at higher probability values but increased less quickly. The pre-test model was defined starting from a pilot sample and represents the basis for a larger MaaS preference model built starting from a larger survey and a sample with a greater number of calibrated parameters.

Keywords: mobility as a service; reviled preference; survey; calibration

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1. Introduction

In this paper, a preference model for mobility as a service (MaaS) is reported. The proposed model can support decision makers and decisions takers in designing a complete survey and model for feasibility studies for planning sustainable transport systems. The specifications of the proposed pre-test model and the preliminary results can be used as a basis for the development of experimentation on a larger scale. The pre-test model is tested with a pilot survey in an area with weak transport demand.

MaaS is important because it allows the use of different modes and services of transport for traveling with adaptive travel demand and the use of a single digital interface. A state-of-the-art example is reported in [1]. A MaaS system has an integrated mobility service and an integrated digital platform for both users and operators (with users at the center of the system). In a transport system, fares and schedule integration, the sharing of a vehicle, information provided to users, and the existence of only joint services are not sufficient to be defined as a MaaS system [2].

In [2], the evolution of a MaaS system is proposed, from an N-MaaS (no transport service integration) to an S-MaaS (sustainable MaaS) composed of the following: transport integration and the availability of an information and communication technology platform

(I-MaaS); a transport decision support system platform (T-MaaS); and sustainability goals, such as those of Agenda 2030 (S-MaaS).

An analysis of the MaaS concept and a state-of-the-art example are reported in Section 2 with a table that contains the main characteristics of the papers analyzed. Some of the papers give a definition of MaaS. Other papers report examples of MaaS experiences in urban contexts, some of them with model calibration. The MaaS literature relative to the calibrated models (Section 2.2) focuses on urban areas; in this paper, a MaaS preference model in an extra-urban area is considered. In this paper, a pre-test model is presented for evaluating user preferences and for testing the feasibility of a MaaS system in an extra-urban context with weak transport demand.

The main objective of the paper is to propose a methodology for immediate application to be implemented with a low budget. The proposed model aims to provide the first indications in a preliminary evaluation step to decision makers and decision takers before starting planning activities. The proposed model hypothesizes two alternatives relating to the preference of users towards MaaS. The construction of the MaaS preference pre-test model is carried out with the following steps: survey, specification, calibration, and validation. The study can be considered as a pilot study and the results need to be confirmed with a larger survey and a more general model. To evaluate the pre-test model presented, a pilot application was developed in the Gioia Tauro area, an extra-urban area in southern Italy. Pilot data were collected in relation to road transport, rail, car sharing, bike sharing, and on-demand services.

This paper is divided into five sections. After Section 1, Section 2 describes the literature review. Section 3 describes the methods used for the specification, calibration, and validation of the pre-test model. To evaluate the applicability of the reported method, the preliminary results and discussion of the adopted pilot survey are reported in Section 4. Section 5 reports the main conclusions.

The main innovation reported in this paper is related to a MaaS preference pre-test model (Section 3) that can be adopted for the estimation of user preference with an immediate response and low budget before a more extensive survey and the more detailed specification, calibration, and validation of choice models. In order to test the applicability of the reported model, a pilot survey and experimentation in an extra-urban area with weak transport demand are reported (Section 4).

2. Literature Review

MaaS has been studied recently and there are numerous published scientific papers. With specific reference to MaaS, this section is divided in two subsections: the first concerns general aspects with particular reference to transport system models, and the second relates to surveys that have been carried out and calibrated models. Section 2.1 contains papers relative to general aspects concerning MaaS, while Section 2.2 focuses on the topic considered in the paper and is relative to the specification, calibration, and validation of demand models relative to MaaS.

2.1. MaaS and Transport System Models

In relation to general aspects, MaaS has recently been defined and investigated. It can be developed in a short time, and it is expected to be increasingly relevant in the future [2]. The first to introduce MaaS was Hietanen [3]. MaaS is the result of a union between transport systems and ICT technologies. In the context of MaaS systems, one of the major problems is due to the need to model user behavior and the consequences of decision makers' actions [4]. In this section, the state of the art is divided in relation to MaaS into the following: its definition and comparison; packages; experiences; supply models; and demand models.

In relation to MaaS definitions and comparisons, the scientific literature on MaaS is expanding and many different MaaS systems have been activated around the world.

- In [5], the MaaS literature (90 scientific publications and 21 MaaS-like schemes) was analyzed to define common elements across its definitions. It emerged that all MaaS systems are based on the use of a single app which allows users to carry out a series of operations, such as organizing a trip, payment, and access to mobility services, through a single channel. It provides information in real time, adapting to changes that services may undergo during the day [5].
- In [6], the literature (127 scientific publications) relative to the topic of MaaS was analyzed. The topic was found to occur consistently from 2018 [6]. Almost all the publications analyzed in the paper [6] were relative to Europe and were often based on research conducted in Sweden and Finland. In the paper, the results were classified according to market, users, data, and technology, as well as to how the world of transport is being transformed. In 39 of the 127 articles analyzed in the paper [6], users were subjected to surveys of their behavior. Age also influenced the attractiveness of MaaS [6], as confirmed in this paper.

In relation to packages, MaaS includes them for different transport modes with different payment methods [5–7]. In [7], the MaaS literature for defining the common elements that characterize a system, such as the integration of transport modes, fare options (bundle or "pay-as-you-go"), digital platforms, multiple actors, the use of technologies, demand orientation, registration requirement, personalization, and customization (the common elements were obtained from a table reported in [7]) were considered. In [1], the state of the art for an electric MaaS system was analyzed: starting from a MaaS system, they proposed an eMaaS system. In [8], the concept of MaaS, as well as the effects of MaaS for territories and citizens considering "environment, health and well-being, and social inclusion", and the consequences on urban governance were analyzed.

In relation to MaaS experiences, these services have been activated in some areas of Europe (i.e., a feasibility study for a MaaS system in London was developed [9]), while pilot projects have been launched in others. In Italy, a national research project for the study of MaaS was launched, a guideline for the development of MaaS in Italy was proposed, and two proposals have been published under the name of "MaaS for Italy" for pilot MaaS systems in metropolitan cities. Three pilot projects are currently supported through the first proposal in the cities of Milan, Naples, and Rome [2], with second proposals supported in Bari, Florence, and Turin.

In relation to transport supply models, MaaS consists of different components, such as institutional, management, immaterial, and material [9]. MaaS supply barriers relate to public–private cooperation, cybersecurity, business support, and coverage of public transport infrastructure [10,11]. In [9], an overview of transport operators in the city of London (such as fares offered, local coverage, and app availability) was considered.

In relation to transport demand models, some models have been analyzed and classified according to different characteristics: bundling according to modal choice, route choice, or both; RP (revealed preference) or SP (stated preference) surveys; or behavioral models or statistical analyses. In research papers, models can be calibrated [12] and the study area can range from a city to an entire country [12]. In [9], travel demand in London with data obtained from the London Travel Demand Survey and an SP-type survey was analyzed. In [13], a carpooling system to allow a reduction in demand during peak hours was studied, and in [14], movements from point A to point B starting from an itinerary with public transport and replacing some links of the network with carpooling (not dealing with the topic of MaaS) were considered. More details regarding the survey and calibration of demand models are given in Section 2.2.

2.2. MaaS Surveys and Model Calibrations

Transport demand models need to be specified, calibrated, and validated with surveys. Table 1 shows some main elements relative to some papers related to surveying and calibrating transport models in a MaaS context.

Table 1. Comparison between papers relative to MaaS surveys and model calibration.

Reference	MaaS Definition	Travel Choice	Survey *	Calibrated Parameters	Study Area
[15]		Mode	SP		The Netherlands
[16]	X		SP	X	Padua (Italy)
[17]		Bundle	RP/SP		Stretto di Messina (Messina Strait, Italy)
[18]		Mode	SP/RP		Stretto di Messina (Messina Strait, Italy)
[19]		Bundle/mode	SP	X	The Netherlands
[20]		Bundle	RP/SP	X	London (UK)
[21]		Bundle	RP/SP	X	London (UK)
[22]		Bundle	RP/SP	X	London (UK)
[23]			RP/SP		Reggio Calabria, Messina (Messina Strait, Italy)
[24]		Bundle			
[25]		Bundle/mode	SP/RP	X	Australia
[26]	X		SP		28 countries
[27]			SP		Edinburgh, Ticino, Brussels, Torino, Zagreb
[28]	X		SP		Canton Ticino, Brussels, Zagreb, and Ljubljana
[29]		Mode-service	RP/SP	X	Cambridge (USA)

* RP: revealed preferences; SP: stated preferences.

In Table 1, the main characteristics considered relevant for the study reported in this paper are as follows: the MaaS definition column refers to the definition of MaaS; the travel choice column refers to the specification of models relative to the choice of transport mode (i.e., individual vs. MaaS) or the choice of bundling within MaaS (i.e., different prices and services for MaaS); the survey column refers to the survey sample which can be relative to either RP or SP surveys; the calibrated parameters column refers to the calibration of the parameters of the demand models specified; and the study area column refers to the study areas considered in the papers.

Most of the papers reported in Table 1 concerned the probability of choosing a bundle. The type of survey was almost always of the SP type regarding calibration of the parameters of the demand models. In 6 out of 15 papers in Table 1 the parameters were calibrated. Most of the papers analyzed considered the following study areas: the Netherlands, London (UK), and the Strait of Messina.

In [15], the propensity for MaaS in the Netherlands was studied through an SP survey. Additionally, in [19] the same type of survey was conducted in the same study area, but in this case, the choice of travel was the bundle. While ref. [16] used the same type of survey, it was conducted in the city of Padua by interviewing municipal employees. In [18], adaptive user behavior in MaaS contexts was considered through SP and RP surveys. In [20,21], the same survey was used to estimate the models (London Mobility Survey); the area studied in both papers was London. In [22], the researchers analyzed the opportunities and barriers to the use of multimodal transport and how MaaS could support its use [22]. In [17], MaaS systems were not explicitly considered; instead, a preference model for the Messina Strait in southern Italy was considered, where there was discontinuity due to the Messina Strait. In the same area, ref. [23] analyzed the willingness to accept MaaS through an SP survey. In [25], a survey in Australia was conducted on a sample of 3985 people [25]. Other authors have not built preference models for MaaS, such as those of [24,26,27]. In [24], a literature review was included and a MaaS bundle design was proposed [24], and in [26], the figure of the mobility intermediary was studied. In [27], willingness to accept "SocialCar" and "new multi.modal mobility service" was studied through an SP survey conducted in five European cities, as reported in Table 1. In [28], intermodal travel consisting of carpooling and public transport to implement a MaaS system in suburban areas was considered. In [29], a demand model starting from data retrieved from smartphones was proposed.

Most of the MaaS literature has focused on urban areas; in this paper, a MaaS preference model in an extra-urban environment with weak demand is reported in the following sections.

3. Methods

The pre-test model proposed in this paper is relative to the preference of MaaS over traditional modes of transport. It can support decision makers and decision takers before the planning and designing of a sustainable MaaS system with more detailed models. For the definition of the model, the adopted method involved the following steps: specification (Section 3.1), calibration from a survey (Section 3.2), and validation (Section 3.3).

3.1. Specification

It is assumed that every user n (n is not reported for simplicity) has 2 alternatives available in choice set **I**:

$$\mathbf{I} = \{\text{yes, no}\} \tag{1}$$

where yes and no refer to the alternative of preferring or not preferring the MaaS scenario in a hypothetical context (stated preference).

Given choice set **I**, the choice of the alternative can be modeled through different models belonging to discrete choice theory, i.e., a random utility model (RUM), a fuzzy UM (FUM), or a quantum UM (QUM). Each user perceives a utility for each alternative belonging to **I** (U_{yes} or U_{no}) and prefers the alternative with the maximum perceived utility. With the reported assumption, the choice probability for the alternatives belonging to I is given by the following:

$$\begin{gathered} p(\text{yes} \mid \mathbf{I}) = probability(U_{yes} \geq U_{no}, \text{yes} \in \mathbf{I}, \text{no} \in \mathbf{I}) \\ p(\text{no} \mid \mathbf{I}) = 1 - p(\text{yes} \mid \mathbf{I}) \end{gathered} \tag{2}$$

In this paper, a RUM is adopted in the Logit family (assumed identical and independent Gumbel probability distribution with parameter θ for the perceived utilities associated to the 2 alternatives). The preference probabilities for the 2 alternatives are as follows:

$$\begin{gathered} p(\text{yes} \mid \mathbf{I}) = e^{Vyes/\theta} / (e^{Vyes/\theta} + e^{Vno/\theta}) \\ p(\text{no} \mid \mathbf{I}) = 1 - p(\text{yes} \mid \mathbf{I}) \end{gathered} \tag{3}$$

where

- V_{yes} is the expected value of utility for the alternative of yes.
- V_{no} is the expected value of utility for the alternative of no.

The ratio between the expected value of utility (V_k with k equal to yes or no) and the Gumbel parameter (θ) are commonly assumed as a linear combination of attributes (X_{1k}, X_{2k}, ... reported in the vector of attributes $\mathbf{X}_k$), with parameters (β_1, β_2, ... , reported in the vector of parameters $\boldsymbol{\beta}$) to be calibrated again during observation:

$$V_k/\theta = \beta_1 \bullet X_1 + \beta_2 \bullet X_2 + \ldots = \boldsymbol{\beta}' \bullet \mathbf{X}_k \qquad \forall\, k \in \mathbf{I} \tag{4}$$

The choice probability for alternative k depends on the vector of the parameters to be calibrated and can be reported as a function $\rho()$ of alternative k subject to **I** and dependent on the vector of parameters $\boldsymbol{\beta}$ to be calibrated:

$$p(k \mid \mathbf{I}) = \rho(k \mid \mathbf{I}; \boldsymbol{\beta}) \qquad \forall\, k \in \mathbf{I} \tag{5}$$

3.2. Calibration

The utilities V_{yes}/θ and V_{no}/θ are specified in terms of attributes and parameters that require calibration from the observed data.

The calibration of the parameters can be carried out through surveys of single users (disaggregated data) or through user flows (aggregated data). The models adopted referring to individual users require the calibration of the vector of parameters with disaggregated RP and SP data and the maximum likelihood approach. Assuming independent observation n, the vector of the calibrated parameters ($\boldsymbol{\beta}^*$) is obtained by the following:

$$\boldsymbol{\beta}^* = Arg\ max_{\boldsymbol{\beta}}\ L(\boldsymbol{\beta}) \tag{6}$$

where

$L(\boldsymbol{\beta}) = \prod_{n=1..N} \rho(k_n \mid \mathbf{I};\boldsymbol{\beta})$ is the likelihood function.
n is the generic user observed (or interviewed).
N is the number of users observed.
k_n is the alternative chosen by user n.

RP consists of the construction of a survey on behaviors revealed or demonstrated in real contexts; SP consists instead of the construction of a survey on behaviors declared by users in hypothetical contexts [30]. A pilot survey conducted on a small sample allows the definition of the size of an effective sample to conduct a full survey, and the results obtained in the study area are reported in Section 4.

3.3. Validation

Informal and formal tests can be considered for model validation.

Among the informal tests, the signs of the calibrated coefficients and their relationships can be verified, i.e., the value of time (VOT) or the ratio between the coefficient relating to time and that relating to monetary cost, which must be consistent with how much users are willing to pay [30]. In a transport alternative, a parameter characterized by a positive sign indicates that a user perceives positive utility in the choice relative to the corresponding attribute (i.e., comfort, quality of service or vehicles, and integration), while a parameter characterized by a negative sign indicates that a user perceives disutility (i.e., travel time or monetary cost). In the case of a model of MaaS preference, the sign of the parameter for distance (or a proxy variable) for a MaaS utility alternative may be positive because MaaS attractiveness can increase with distance.

Among the formal tests, there is that of Student's t-test of single coefficients, which verifies that the estimated parameters are equal to 0. This test establishes that a parameter estimate is significantly non-zero if the statistical test is not accepted [30]. This test is helpful in the calibration phase for evaluating if an attribute needs to be tested in different specifications; a high value of a constant indicates that there are other attributes of attractiveness or costs to be considered. The statistic for each parameter h is evaluated by the following:

$$t_h = \beta_h^* / \sigma(\beta_h^*) \tag{7}$$

where

β_h^* is the parameter h estimate using the maximum likelihood method and $\sigma(\beta_h^*)$ is the standard deviation relative to β_h^*.

Another formal test is the goodness of fit of a model ρ^2. This depends on the likelihood function evaluated with the vectors of calibrated parameters with optimal and 0 values. The values are in the range of [0; 1] in relation to the model reproduction of the choices of the sample [30]:

$$\rho^2 = 1 - ln(L(\boldsymbol{\beta}^*))/ln(L(\boldsymbol{\beta}^0)) \tag{8}$$

where

L is the likelihood function; $\boldsymbol{\beta}^*$ is the vector of the optimal values of the calibrated parameters; and $\boldsymbol{\beta}^0$ is the vector of the calibrated parameters equal to zero.

Other formal tests can be adopted, such as the Chi-squared test for the vectors of coefficients, the likelihood ratio test for the vectors of coefficients, and a test for the functional form of a model [30].

4. Results and Discussion

The experimentation aimed to test and validate the specified pre-test model reported in Section 3 and to test the validity in an extra-urban context. This section aims to investigate the willingness of users to use MaaS systems instead of private vehicles with a pre-test model in urban or extra-urban areas, as well as their willingness to pay to use an alternative to private vehicles with a pilot study.

The territorial context analyzed in the experiment was in the extra-urban area of Gioia Tauro in the Metropolitan City of Reggio Calabria in southern Italy. The 33 municipalities of the Gioia Tauro area were divided into five zones by merging neighboring municipalities. Considering the city of Gioia Tauro as the center of the study area, it is approximately 55 km from the Metropolitan City of Reggio Calabria. Approximately 150,000 people live in the Gioia Tauro area, while the extension of the territory is approximately 1000 km^2 with a density of approximately 150 inhabitants/km^2.

In accordance with [31], an indicative threshold was identified in order to be able to define an area characterized by low population density that corresponded to 50 inhabitants/km^2: 9 municipalities out of 33 belonging to the study area were below this threshold. In the study area, the transit mobility services consisted of road services and rail services. The former consisted of buses, car sharing, on-call services, and bike sharing. The road bus services were managed by approximately 15 companies. The rail services were managed by one company. The transport systems in the area were low-frequency transit. In some timeslots, was not possible to reach a destination by transit transport. For this reason, it was decided to study the possible introduction a MaaS system in the area and to analyze user preferences.

4.1. Scenarios and Survey

A survey aimed at a pilot sample of users was designed and carried out.

The survey form had 22 questions grouped into three sections:

- Macro-user data, such as age range, number of household members, and vehicle availability.
- The most frequent journeys, origins, destinations, methods, and frequencies of use of local public transport systems.
- What-if scenarios (Table 2).
    a. Scenarios 1 and 2 were (extra-urban) long distances (from the Gioia Tauro area to the Metropolitan City of Reggio Calabria and vice versa):
        i. Scenario 1 considered trips between the Gioia Tauro area and the Metropolitan City of Reggio Calabria in extra-urban areas.
        ii. Scenario 2 was the same as scenario 1, considering also that, in the present configuration, users pay a monthly subscription for parking a car. This was asked to understand if a user would prefer to pay for parking rather than buying a MaaS package, as in the previous case.
    b. Scenario 3 (suburban) was a short distance (inside the Gioia Tauro area) considering trips within the Gioia Tauro area in suburban areas.

Table 2. Services considered in the bundling of subscenario B.

Area—Distance	Extra-Urban—Long Distance		Sub-Urban—Short Distance
Scenarios (Sub Scenario B)	**1**	**2**	**3**
Suburban Bus (Monthly Subscription)	1	1	1
Urban Bus (Monthly Subscription)	1	1	0
Car sharing (30 min)	4	4	4
On-call service (h)	0	0	2
Bike Sharing (Two days mobile)	2	2	2
Train (Monthly Subscription)	1	1	0
Bundle Cost for MaaS (EUR/month)	135	135	90

Each scenario (1, 2, and 3) included three subscenarios (A, B, and C) with different services at different costs. Subscenario B considered a 33% reduction in cost (EUR/month) compared to the fare for individual services. Table 1 shows the services considered for subscenario B. The cost (EUR/month) and the frequency of subscenarios A and C compared to subscenario B were assumed as follows:

- In subscenario A, by reducing the price of the package by 25% and the frequency by 50%.
- In subscenario C, by increasing the price by 25% and the frequency by 50%.

The pilot sample included 21 users living in the study area. The sample size was within the range expected for this type of pre-test and pilot study. Small samples (between 10 and 30) in pilot and exploratory studies have the advantages of economy, simplicity, and easy calculation [32]. In [33], some considerations regarding the confidence intervals evaluated by pilot studies were reported; a sample size of 10–40 individuals per group can be used for a variety of objectives.

The survey was carried out for the sample group by experts in the transport area and MaaS. The experts showed the users the scenarios and their bundles. The questionnaire was not disseminated through a computer system with an automatic procedure, obtaining a large sample. The presence of an expert during the interview made it possible to clarify some questions posed by the interviewees on the subject and allowed us to obtain more reliable responses. Users spent at least 30 min of their time listening to an explanation of MaaS and were able to ask the experts for clarification.

For compatibly within the small size of the sample, the users interviewed were adults with an average age similar to that of the entire population. Furthermore, in order to obtain the majority of users from the extra-urban area of Gioia Tauro, approximately 71% had a systematic origin of trips in the area of Gioia Tauro, and the others had systematic origins in the remaining area of the Metropolitan City of Reggio Calabria.

The answers were treated anonymously. For this reason, for example, age was not asked but the users were simply asked to place themselves within one of the established age groups. In addition, the origins and destinations of journeys were asked in terms of zone. Users were asked to answer regarding their most frequent journey for the presented configurations of the three what-if MaaS scenarios (1, 2, and 3) and sub-scenarios (A, B, and C). For each scenario (1, 2, and 3), users were asked whether or not they were willing to buy options A, B, and C (yes or no for each subscenario).

To support the model specification, calibration, and validation phase, a statistical analysis of the results deriving from the survey was carried out. In relation to the reason for the usual journey, 24% made their usual journey for "Study" and 33% for "Work". In relation to mode, 76% used a private car.

Considering a one-way trip and the survey data, in scenarios 1 and 2 (extra-urban) the average travel time was 80 min and the average distance travelled was 60 km; in scenario 3, the average travel time was 30 min, and the average travel distance was 30 km.

4.2. Specification

In each scenario, each user expressed one preference for each subscenario (A, B, or C), and for each subscenario, a binomial Logit preference model was specified. The expected utility value associated with each subscenario preference had the following specification:

$$\begin{gathered} V_{si}/\theta = \beta_{bundle\_cost} \bullet bundle\_cost + \beta_{age} \bullet age + \beta_{scenario} \bullet scenario + \beta_{constant} \\ V_{no}/\theta = \beta_{time} \bullet time \end{gathered} \tag{9}$$

where

- β_{bundle_cost}, β_{age}, $\beta_{scenario}$, $\beta_{constant}$, β_{time} are the parameters to be calibrated.
- *bundle_cost* is the cost of the bundle in a specific subscenario.
- *age* is equal to 1 if the user is younger or equal to 45 years and 0 if older.
- *scenario* is one if the user prefers more than one subscenario in the scenario and zero otherwise, and the variable can be considered as a label.
- *time* is the sum of the access or egress time, waiting time, and travel time from the origin area to the destination area of the user's usual journey.

4.3. Calibration

For each scenario, four specifications (identified as I, II, III, and IV) were calibrated. The results derived from the maximum likelihood method are reported in Table 3.

Table 3. Values of the calibrated parameters.

Scenario (1..3)	ID (I..IV)	β_{time} (Util/h)	β_{bundle_cost} (Util Month/€)	β_{age} (Util)	$\beta_{scenario}$ (Util)	$\beta_{constant}$ (Util)	ln(likelihood) * (Optimal β)	ρ^2 [0, 1]	VOT (Euro/h)
1	I	−1.883 (−2.914)	−0.013 (−3.257)				−37.2	0.14	150
	II	−1.586 (−2.327)	−0.016 (−3.294)	0.921 (1.409)			−36.1	0.17	100
	III	−1.706 (−2.185)	−0.052 (−3.920)			5.573 (3.345)	−30.2	0.30	33
	IV	−0.658 (−0.686)	−0.078 (−3.843)		3.874 (3.138)	8.391 (3.541)	−21.8	0.50	8
2	I	−0.545 (−0.975)	−0.002 (−0.782)				−43.2	0.01	218
	II	−0.121 (−0.196)	−0.005 (−1.449)	1.023 (1.746)			−41.6	0.04	22
	III	−0.203 (−0.302)	−0.042 (−3.693)			6.137 (3.631)	−34.4	0.20	5
	IV	−0.392 (−0.472)	−0.066 (−3.738)		3.453 (3.432)	7.049 (3.245)	−24.4	0.44	6
3	I	−2.199 (−3.231)	−0.021 (−3.438)				−36.0	0.17	105
	II	−1.745 (−2.348)	−0.034 (−3.674)	2.056 (2.639)			−31.3	0.28	51
	III	−2.213 (−2.582)	−0.093 (−4.090)			6.479 (3.547)	−27.6	0.36	24
	IV	−1.027 (−0.991)	−0.128 (−3.956)		3.403 (2.887)	8.822 (3.680)	−21.2	0.51	8

* ln(likelihood) = −43.7 with parameters equal to zero. For each parameter, the results of *t*-test are presented in parentheses.

4.4. Validation

The time parameter had a negative sign (present in the no alternative). In fact, as time increased there was a greater propensity to choose the MaaS alternative. The bundle cost parameter had a negative sign because the higher the bundle cost, the lower a user's propensity to purchase MaaS packages. The scenario parameter state had a positive sign because the utility increased with the number of subscenarios chosen. All the calibrated models were acceptable in terms of the signs of the parameters.

The VOT varied from a maximum of EUR 150 to a minimum of EUR 8 for scenario 1, from a maximum of EUR 218 to a minimum of EUR 6 for scenario 2, and from a maximum of EUR 105 to a minimum of EUR 8 for scenario 3. The best results were those characterized by a low VOT, consistent with the users surveyed who traveled for work, study, or other reasons, such as errands or leisure. The best calibrated models in term of VOT were III and IV.

The Student's *t*-test established that a parameter estimate was significantly non-zero if the value did not belong to the range between −1.96 and +1.96 with the statistical significance of 95%, assuming that the value was distributed according to a standard normal variable [30]. In the calibration of scenario 1, according to this formal test, the β_{age} of model II and the β_{time} of model IV were not significant. In the calibration of scenario 2, on the other hand, the β_{bundle_cost} was significant, as well as the $\beta_{constant}$ of model III and the β_{bundle_cost}, $\beta_{scenario}$, and $\beta_{constant}$ of model IV. In the calibration of scenario 3, the parameters were all obtained as significant except for the β_{time} of model IV.

The indicator ρ^2 was zero if two functions were equivalent, and it was one if instead a model predicted a probability equal to one when observing the choice actually made and declared by each user. Therefore, if ρ^2 was 1, the model reproduced the choices of the sample [30]. The highest ρ^2 was obtained with the specifications of IV for the three scenarios. Some calibrations had very low indicator values but are reported to provide comprehensive and comparable information across different scenarios and subscenarios.

4.5. Probability and Elasticity

Figure 1 shows the variability in the MaaS preference probability with specification I for scenarios 1 (black line), 2 (red line), and 3 (blue line) and subscenarios A (continuous line), B (dotted line), and C (pointed line). The long-distance scenarios (1 and 2) are reported in Figure 1a while the medium-distance scenario (3) is reported in Figure 1b.

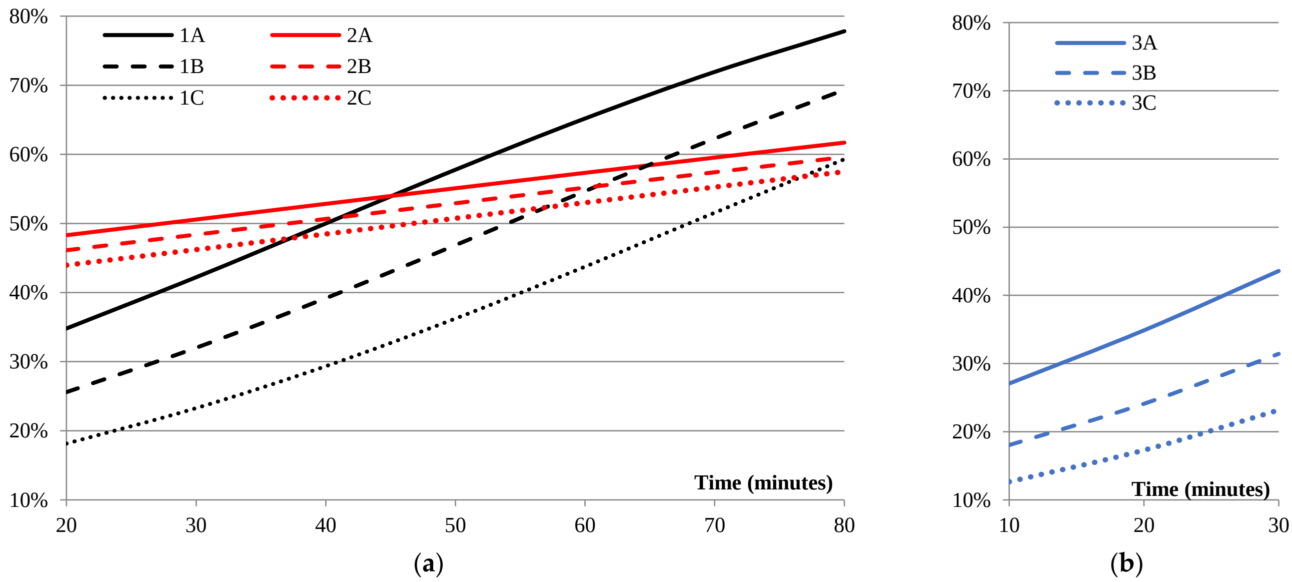

Figure 1. MaaS choice preference (%) with calibration model I: (**a**) scenarios A and B (long distance) and (**b**) scenario C (short distance).

The MaaS preference probability increased with travel time in the current alternative (negative value of the time parameter in the current alternative's utility) and decreased with increasing bundle cost (negative value of the parameter of cost in the MaaS alternative). The MaaS preference probabilities had similar values for scenarios 1 and 2 with the same travel time. Scenario 3 had a shorter travel time and had lower preference than scenarios 1 and 2. This result provided information on users and how they behave similarly for short and long distances in the absence of additional parking costs in the presented scenario. The elasticity values evaluated as the ratio between the percentage change of the probability and the percentage change of time were approximately 0.65 for scenario 1, 0.15 for scenario 2, and 0.75 for scenario 3.

In the case of the cost of parking, the behavior was different. In fact, for scenario 2, compared to scenarios 1 and 3, the probability of preference for the MaaS scenario started from higher values for low time values and grew less rapidly. The probability had a narrow range of variation compared to other scenarios with fixed travel times. The cost of additional parking greatly favored preference for the MaaS scenario.

4.6. Discussion

Most of the MaaS literature reported in Section 2 referred to urban areas characterized by high-frequency and multimodal transport services. In this paper, the attention has been shifted from the urban to the extra-urban context characterized by weak transport demand

and low-frequency transport services. The main objective of the paper was to propose a pre-test model for a preliminary evaluation of a MaaS system in an extra-urban context.

The proposed pre-test model had general validity in terms of specification and can be used to evaluate choice preference for the introduction of a sustainable MaaS system when an immediate response is required with a limited budget. The experimentation was carried out through a pilot sample and, therefore, can be used in the study area as a pre-test model in the feasibility step for the wider planning process of transport systems.

Considering also that this was a pilot survey and a pre-test model, the results can give some policy indications to decision takers and decision makers in the study area. Decision takers can use the pre-test model and the pilot study for support in the decision to proceed or not with the planning of a MaaS system through more extensive and in-depth studies. Decision makers can use the model and the pilot study for the design of an extended investigation and the calibration and validation of more advanced models in relation to the objectives and goals defined by decision takers.

A sustainable MaaS system cannot be achieved by adopting existing services and integrating them only through an information and communication technology system. A sustainable MaaS system must be planned and designed through the use of quantitative methods and models used in transportation engineering for estimating performances with simulations of user behaviors to achieve sustainable goals.

If it is necessary to evaluate the realization of a transport service that does not exist in a study area and is not present in similar territories, a survey using a large sample that builds detailed transport models can require significant implementation times and costs. The pilot sample and the pre-test model proposed in this paper fit into the preliminary evaluation phase when decision makers and decision takers want to understand if a system can be implemented and what to focus on for subsequent evaluations. The sample size considered in this paper was in the range considered for pre-test and pilot studies ([32,33]).

The model calibrated reproduced quite well the choices declared by users during the survey. In confirmation of what has emerged from other analyses mentioned in the text, bundles were more attractive for users who made journeys characterized by longer journey times and were less so for those who made short journeys. The attractiveness grew with the travel time and decreased with the cost of the package. The additional cost in the present scenarios influenced the preference for bundle cost. Considering the parking cost in a presented scenario (scenario 2), the MaaS preference probability started from higher probability values but increased less quickly.

The results obtained in terms of statistical indicators confirmed that with a pilot sample and the calibration of a pre-test model, preliminary information could be obtained regarding the possible feasibility of a MaaS system and the relevant variables to be further analyzed by means of a wider investigation and the calibration of a more in-depth model.

A pilot sample of users was considered and the following results obtained are to be considered preliminary and referred to the extra-urban context analyzed: the MaaS preference has a high variability, from 20% to 80%, and requires further investigation considering the small sample size; the MaaS preference increases with the travel time of the chosen travel alternative without the presence of the MaaS system; the elasticity is slightly influenced by travel time and is strongly influenced by price; and the MaaS preference is also influenced by a preference of the sample users towards MaaS, not directly linked to travel time and price.

5. Conclusions

In this paper, a Logit model was proposed for evaluating the preference for MaaS in an extra-urban context with weak demand. The model was specified, calibrated, and validated using a small sample size. The main purpose of the paper was to evaluate the possibility of using a model of this type for the design of a future, more extensive investigation. The model was considered as a pre-test model. The specification had general validity. The attributes to consider in utility had to be selected case by case. Even the calibrated parameters and the relative numerical results were valid only for the specific case study in a pre-test model phase.

The model was tested in the area of Gioia Tauro in the south of Italy. In the study area, shared mobility services, such as bike sharing and car sharing, were not widely available. This was confirmed during the pilot survey by the interviewees: 76% traveled in their own cars, 38% never used public transport, and only 5% used local public transport every working day. In the survey, three MaaS scenarios (named 1, 2, and 3) each with three subscenarios (named A, B, and C) with increasing frequency of transport services and bundle cost were proposed to users. From the pilot survey, a Logit model was calibrated and validated with the maximum likelihood method considering four specifications for each scenario (I, II, III, and IV). In the first specification, two parameters were calibrated: one referring to time and one referring to cost. In the second specification, the age parameter was also calibrated. In the third specification, the constant parameter was calibrated with respect to the first specification. In the last specification, the label relative to the scenario was calibrated with respect to the third specification. From the first to the fourth specification, the VOT decreased while the ρ^2 increased. Consistent with the class of users surveyed, the fourth specification had better results, but the time parameter was not statistically significant based on a Student's *t*-test at a 95% confidence level.

In the case study, for long-distance journeys without parking payment in the current scenarios and for short-distance journeys, the elasticity was approximately 0.65, with highly variable preference probabilities (MaaS preference between 20% and 80% increasing with travel time). For long-distance journeys with parking payment in the current scenarios the elasticity was approximately 0.15 (MaaS preference around 50% slightly increasing with travel time).

These results indicate that the preference for MaaS grew with the increase in travel time and was strongly influenced by the price of the bundle. From the utility specifications, it can be observed that the inclusion of the 'scenario' variable led to a significant increase in the ρ^2 statistic (from 0.30 to 0.50 in scenario 1, from 0.20 to 0.44 in scenario 2, and from 0.36 to 0.51 in scenario 3). This variable had a positive sign in the calibrations in the case study. It was a label and an indicator of the preferences of sample users toward MaaS, and the variable was not necessarily linked to service-level variables.

The model has limits to be developed in future works. It was based on a pilot sample and, due to the small number of interviews, it was not possible to calibrate a greater number of parameters or other typology of random utility models, which would have allowed us to obtain a greater amount of information relating to MaaS.

The model must be considered as a pre-test model useful for designing a larger sample and a more general preference model. This work should be considered preliminary and could be the basis for building a MaaS preference model and carrying out a larger survey in order to calibrate a greater number of parameters considering the results obtained in this paper. Furthermore, other types of choice models could be specified and tested, as well as considering possible covariance between alternatives.

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