ASSESSING THE PROPENSITY TO CAR SHARING SERVICES IN UNIVERSITY CITIES: SOME INSIGHTS FOR DEVELOPING THE CO-CREATION PROCESS

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Resume

Cities are often characterised by the presence of universities and by a greater number of students, often commuters, with an average age of less than 30 years. The study focused on the city of Enna (Italy), where the university students represent a significant percentage of residents and also a good rate of local travel demand. The survey campaign was conducted over a period of more than one year. A bivariate statistical method was applied highlighting significant variables regarding several features of a car sharing system. Additionally, non-parametric statistics and a before and after analysis were performed to evaluate the influence of implementation of the shared transport service. The results can also offer insights into the improvement of transport supply in urban context and the possible implementation of the co-creation actions between the companies managing the service with the end-users.

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1 Introduction

The continuous evolution of urban transport models is characterised by different sharing transport systems i.e. car sharing and bike sharing that are particularly attractive and constantly updated themes [1-2].

A correct design of sharing mobility systems provides an optimal basis for implementation of Mobility as a Service (MaaS) systems, useful for all age groups and which make it possible to streamline booking procedures and waiting times in changing the mode of transport, also considering the new transport mobility issues deriving from the COVID-19 pandemic and the evolving transport demand [3-4]. An increasing safety related to this mode of transport can be guaranteed both by carefully studying the variables that characterise the transport demand or further measures to the restriction of the private vehicle use for decarbonisation strategies.

The use of one's own car is also connected to increasing economic, social and environmental costs. In fact, the ever-increasing transport demand, effectively involves enhancing the attention to systems capable of "intelligently" addressing the mobility problems in their entirety, by allowing more effective and efficient overall performance of the system, using appropriate mobility planning and management strategies [5-6] and implementation of innovative transport systems [7]. One strategy, linked to benefit in terms of innovation and low costs, is to create vehicle sharing institutions. Shared transport demand is strongly influenced by some external factors such as population density, age, family size, level of education, proximity to public transport stations, land use, distance from the central business district, distance from services, number of companies close to the stations and vehicle availability. Authors of [8] show the impact of demographic, environmental, economic and travel models on the adoption of vehicle sharing systems. The efficiency of the implemented system is based on the correct design and location of the stations.

The optimisation of the transport offer is done by considering the end user as a user as well as a potential helper during the decision-making process, implementing what is called co-creation. The term co-creation refers to involvement of users and stakeholders during the product design and development process. Co-creation

is a very broad term and emphasises the collective creativity of stakeholders, designers, researchers and end users [9]. Some authors have identified the co-creation as the composition of co-production and co-design, while others have referred to co-creation as a particular case of co-design [10].

Several researches have highlighted the importance of networks and configuration of relationships and resources in markets. In particular, the creation of value is a complex and multidimensional process that is best studied in the context of dynamic networks or ecosystems of exchange of services. The concept of co-creation has been advanced by several value research from a service ecosystem view, considering the importance of networks and the configuration of relationships and resources in markets [11-12].

In the field of mobility, a bottom-up approach to participatory planning is essential in order to improve cooperation between citizens and politicians and to take into account the critical issues that users encounter on a daily basis [13-15].

In studies [16] and [17] authors focused their research on the relationship among sharing service, forecasting, optimization and personalization actions.

The evolution of shared mobility starts from traditional forms such as taxi, car rentals and public transport [18] and expands through the diffusion of new business models and concepts. In this perspective, the growing development of new forms of one-way mobility or free-floating car sharing is spreading in Europe and America [19]. Car sharing generates benefits for the community and for certain population groups, such as young people who do not own a car [20]. Indeed, this service allows journeys to be made without a need to purchase a vehicle [21]. Moreover, the diffusion of car sharing service implements a mitigation intervention regarding the dependence on private cars, with economic and environmental impacts as well as potential health benefits that can be obtained from this emerging mode of transport [22-23].

Currently, many systems are adopting electric vehicles that require charging only when battery levels drop below a certain value. In order to improve the service, in accordance with [24], a model was evaluated which considers the assignment of cars to charging stations and the path of staff and service vehicles by optimising the service.

Consequently, to promote a more sustainable development of urban areas characterised by expansion of university centres, it is considered that the diffusion of the shared transport service, in parallel with the diffusion of the public transport service, can improve travel, especially when the student population is almost represented by foreign students or commuters. The attributes of potential users of this system have been studied in this research in order to maximise its effectiveness. A survey of a number of attributes was conducted in order to know and model the propensity of university students to join the car sharing. Mixed data collected from Internet and paper surveys were used to understand the preferences of early adopters for this shared transport service and to assess the subsequent extension of the service to the whole population.

Furthermore, through a before and after analysis, it was possible to compare the results of the survey following the implementation of the car sharing service and influences that this had on the opinions of the interviewees.

The document is divided into 4 sections: Section 2 with the analysis of literature on the evolution of the shared transport system and demand modelling analysis; in Section 3 is defined the sample acquisition methods and the statistical analysis methodology used; in Section 4 the results are compared and finally conclusions and evolutionary hints of this research are provided in Section 5.

2 Literature review: the sustainability of car sharing services implementation

Compared to the last decade, Europe is experiencing a positive development of car sharing in terms of number of cars and number of users. At present, Europe represents around 50 % of the global car sharing market and is expected to reach 15 million users by 2020.

Europe highlights that car sharing is popular in cities with a high level of education or university presence and, in cities where business-to-consumer (B2C) takes place and in cities where there are many people with green ideals and ecologists [25]. In addition, the car sharing is getting less choice in cities where there are many automotive commuters. The introduction of innovative mobility services, such as car sharing, leads to changes in users' travel habits, inducing a shift in travel demand from existing travel arrangements. An analysis of these changes should be performed to promote the car sharing, effectively managing the travel demand.

The recent pandemic has altered the travel habits of users due to both restrictions and the growing fear of contagion [26-27]. The months following the lockdown (March-May 2020) were characterised by an increase in the use of private vehicles, reducing the successes of the decarbonisation campaigns implemented prior to the pandemic [28]. Some categories of users such as students and workers have reduced travel from March to December 2020 due to distance learning and teleworking [29]. A small number of studies have considered future compulsory student travel, which constitutes a large part of daily travel and is crucial for the development of a society, by analysing available travel alternatives and specific risk mitigation measures on vehicles, as well as the promotion of shared or alternative mobility [30].

The variables investigated in this manuscript allow to lay the foundations for an improvement of the

service in the post-pandemic phase: in fact, it is known that the car sharing offers a way to stay on the move while maintaining distance during the Coronavirus pandemic, especially without an own car. It also offers the possibility of having one's own car at short notice, without the financial commitment of owning one. This service is optimal for areas, such as the one examined, where the weather conditions together with the high slopes do not allow one to move easily on foot and/or by bicycle. To identify the travel attributes that affect the intention to switch to car sharing, estimates can be used through the decision trees for each mode of transport. In fact, in accordance with [31], it is clear that the threshold values of each variable that induce a modal shift are specific to the mode and therefore provide better information useful for calibrating the best political and economic actions aimed at increasing the benefits of car sharing. The social component, defined by students and in particular by those who attend universities, in general is very receptive to the concept of sharing economy and therefore university students are recognized as a potential group of customers for car sharing operators.

A study focusing on Belgrade university students reveals that the student population has provided a homogeneous response regarding critical aspects of service adoption such as costs, distance from vehicles and convenience of parking. Specific attributes, such as the pricing scheme and vehicle cleaning, are particularly interesting problems in the study market [32].

Some universities in California offer commuter students free use of shared vehicles across campus for a certain period of time, so car-sharing is very popular with bus commuters, college students and women employees [33]. In order to improve the car sharing transport offer for university students it is necessary to consider a series of socio-economic variables, but it is also important to understand both the unique characteristics of academic institutions such as markets for car sharing and the ways to predict the university demand for car sharing services.

The design of a balanced survey, hard-copy and online format, allows researchers to investigate the transport habits and car sharing preferences of university affiliates and the propensity to use the car sharing service. Studies prepared over the past decade showed that the status of an interviewee at the university (e.g. faculty, student or staff) had a strong influence on individual acceptance of car-sharing, even more so than the socioeconomic variables, such as income or property. Vehicles and people's attitudes play an important role in their decision making [23]. Different types of the car sharing services affect the travel behaviour (choice and frequency) and this depends on the type of user. Several factors have changed the travel habits and modal choices over time, e.g. the recent COVID-19 pandemic or the spread of Mobility as a Service (MaaS) platforms.

Several studies in the literature show such trends through before-and-after modelling; in particular, according to [34] the sustainability of shared mobility in the post-pandemic phase has been considered through two levels: at the level of travel behaviour and at the level of urban infrastructure. In contrast, research conducted by [35] investigated the effects of car sharing by considering trends in transport-related emissions at the individual and city level.

With regard to bivariate modelling, a research focused on the city of Turin focused on estimation of cars haring services, estimating the propensity to have a car sharing subscription and substitution patterns between different means of transport for a representative sample of trips made by the population of Turin through the bivariate models [36].

In agreement with [37] an ordered bivariate profit model was implemented to better understand the influence of various exogenous socioeconomic and demographic variables on the frequency of use of ride-sourcing and car-sharing services.

This work is focused on a correlation of variables related to location of the sample's place of residence (distance) by relating this variable to the concept of car-sharing utility and fare selection. The results made it possible to combine the socio-demographic or purely user-specific aspects with typical characteristics of the pricing of the service and the interconnected distance between the places of residence/work and the car parks where the shared cars are parked.

3 Materials and methods

The methodological framework of the research is represented in Figure 1.

First of all, a survey was carried out in order to retrieve a number of information and measures. Then, the obtained data were processed and analyzed through a statistical bivariate analysis (the first step) and a before and after analysis (the second step).

In the first part of the analysis, after the definition of main and secondary variables, the computational procedure for the assessment of multiple dependence or independence between variables was characterised by six steps, including primarily the calculation of the Cronbach alpha.

Subsequently, in the second step, the survey was re-proposed and statistical tests were implemented, i.e. Wilcoxon and Friedmann, by comparing the "before" and "after" answers. Moreover, judgement criteria were identified based on which the percentages of variation in the opinions of the interviewed users were assessed.

The following subsections provide more details on the methodological aspects regarding the structuring and implementation of the questionnaire and the performed statistical analysis.

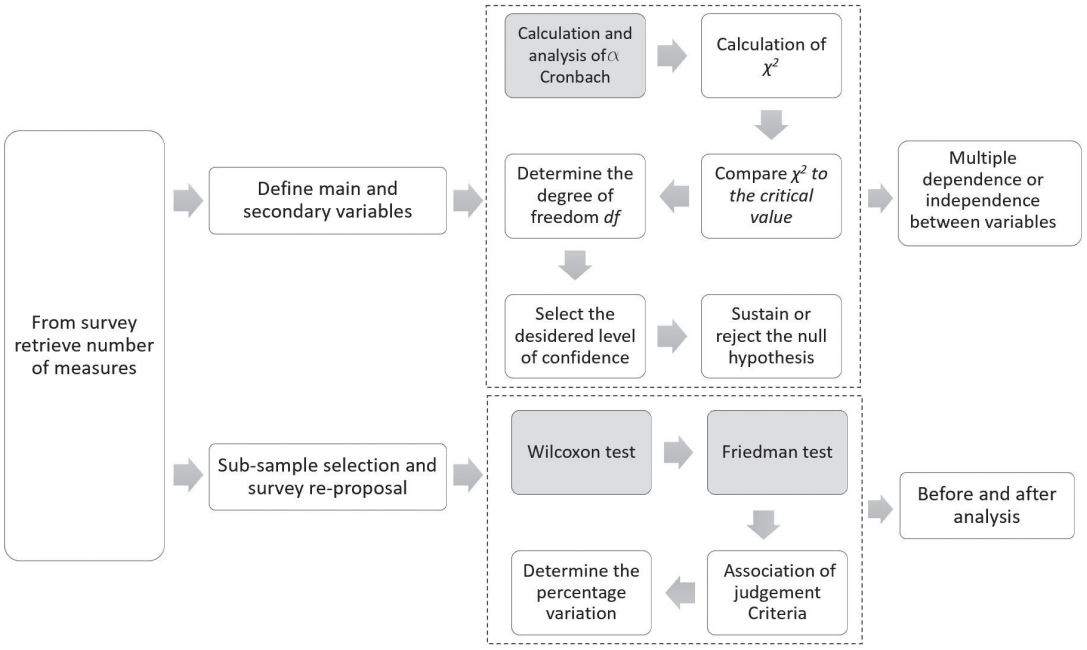

Figure 1 *Methodological framework*

3.1 Questionnaire design and data collection

The questionnaire was structured in four sections, investigating different variables:

- the first section was related to socio-demographic data (i.e. gender, age, car and driver licence ownership; attended university);
- the second one was linked to geographical information (i.e. residence and domicile);
- the third section investigated the travel behaviour (i.e. transport modes for home/school and home/leisure trips; bus use frequency);
- the fourth section analysed the shared mobility experience. This last section investigated previous experiences linked to car sharing (e.g. in Italy; abroad with electric or hybrid vehicles); the propensity to use alternative vehicle power supply; and aspects related to the car sharing service (i.e. way of reservation; rate; service subscription). Finally, the experience and propensity to use the implemented car sharing service in the case study area were evaluated.

The questionnaire was drawn up considering different types of approach to the response, that is, through both Internet and paper surveys and a single, multiple or Likert scale response. The rating system of Likert scale [38-39] was used to structure answers in ordered scale (e.g. "absolutely no", "absolutely yes" for answering the question about the proposal of a new car sharing service), wherever it was possible, in order to assess the subject's perception.

The sample was characterized by a specific group of users consisting of university students. The size of the sample can be considered significant, as it is representative of almost the entire student population. Furthermore, a sub-sample was randomly selected and was subjected to a double investigation before and after the advent of the car sharing service in the study area.

3.2 Bivariate analysis

A bidimensional or bivariate analysis was developed to study the influence of different variables in joint car sharing service, from a sustainable perspective.

The main variables, related to economic, environmental and social points of view, were associated with several secondary variables and Pearson's chi squared test was calculated considering pairs of these variables [40-41]. Selected variables included three major aspects: influence of socio-demographic data (e.g. gender; car ownership), travel behaviour (e.g. transportation mode for daily trips) and attributes related to experiences with car sharing and willingness to join it (e.g. car sharing experience in Italy and abroad; rate selection; car sharing utility). Specifically, three main variables were associated to each combined correlation with several secondary variables, as reported in Table 1.

The concept of probabilistic independence on which this study was based is represented by the following assumptions:

$$H_0: P(AB) = P(A) \times P(B), \quad (1)$$

$$H_1: P(AB) \neq P(A) \times P(B), \quad (2)$$

where:

- H_0 is the null hypothesis;
- H_1 is the alternative hypothesis;
- A and B the two correlated variables.

Table 1 *Bivariate attributes and specific correlations between main and secondary variables*

Correlation	Main variables	Secondary variables
C1- 1	1. Place of residence (Distance)	1 - Mode of transport for home/school
C1- 2		2 - Mode of transport for home/leisure
C1- 3		3 - Car ownership
C2- 1	2. Car Sharing utility	1 - Gender
C2- 2		2 - Car ownership
C2- 3		3 - Place of residence (Distance)
C2- 4		4 - Mode of transport for home/school
C2- 5		5 - Mode of transport for home leisure
C2- 6		6 - Car sharing experience in Italy
C2- 7		7 - Car sharing experience abroad
C3- 1	3. Rate selection	1 - Gender
C3- 2		2 - Place of residence (Distance)
C3- 3		3 - Mode of transport for home/school
C3- 4		4 - Mode of transport for home/leisure
C3- 5		5 - Car sharing experience in Italy
C3- 6		6 - Car sharing experience abroad
C3- 7		7 - Car Sharing utility

To test the association between the two categorical variables and verify the null hypothesis H_0 that the samples are independent, the data were organized in a table of contingency g x k, a chi-square χ^2 was derived from:

$$\chi^2 = \sum_{i=1}^{g}\sum_{j=1}^{k}\frac{(n_{ij}-E_{ij})^2}{E_{ij}} = \sum_{i=1}^{g}\sum_{j=1}^{k}\frac{n_{ij}^2}{E_{ij}} - n, \quad (3)$$

with $n = \sum_{i=1}^{g}\sum_{j=1}^{k} n_{ij} = \sum_{i=1}^{g}\sum_{j=1}^{k} E_{ij}$

where:
- n_{ij} is the number of observed cases in sample j and which correspond to the i-th mode;
- E_{ij} is the number of expected cases in sample j and for the i-th mode if H_0 is true;
- g is the number of modes in which the main variable is expressed;
- n it is the number of all the samples put together.

Due to the hypothesis of independence of the samples, the number of expected cases was calculated with:

$$E_{ij} = \frac{n_j n_{i.}}{n}, \quad (4)$$

with:
- $n_j = \sum_{i=1}^{g} n_{ij}$ is the marginal frequency for each of the g modes;
- $n_{i.} = \sum_{j=1}^{k} n_{ij}$ is the number of each sample.

Before calculating the chi-square χ^2, the Cronbach alpha was calculated for each correlation, in order to measure the internal reliability of the questionnaire, Equation (5), [42], with particular reference to the quantitative variables (or items) and using the Likert scale:

$$\alpha = K \cdot \frac{\underline{r}}{1 + (K+1)\cdot \underline{r}}, \quad (5)$$

where:
- K is the number of items;
- $\underline{r}$ represents the mean of the correlations.

The formulation has been adapted for the case of dichotomous variables (or items), as follows:

$$\alpha = \frac{K}{K-1}\cdot\left[1 - \frac{\sum p\cdot q}{\sigma_t^2}\right], \quad (6)$$

where:
- K is the number of items;
- p is the proportion of items with coding equal to 1;
- $q = 1 - p$;
- σ_t^2 is the variance.

3.3 Before and after analysis

The before-and-after analysis (B/A analysis) constituted of a non-experimental design, which is very suitable for the purposes of this study, since it is a reasonable option for an evaluation to provide preliminary evidence for an intervention effectiveness [43-44].

Specifically, in this study a B/A analysis of this type "OXO" was applied to assess the level of causality of the two measurements Oi and Oj having in the middle the introduction of the intervention X, i.e. the implementation of the car sharing service in the study area. The percentage of response variation before

and after the intervention was calculated and it was compared to a judgement criterion associated with each variable, to be able to assign a negative or positive value, from a multiple perspective (i.e. economic, social and environmental).

Additionally, since the statistical analyzed subsample for the B/A analysis was derived from the same group population, the Wilcoxon non-parametric test was applied to verify, in the presence of ordinal values with a continuous distribution, if the judgments undergo a variation following implementation of the intervention X. The test involved calculating the statistical variable U, which has a distribution under the null hypothesis determined by the following equation:

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}, \tag{7}$$

where:

- n_1 is the sample dimension of the sample interviewed before the intervention X;
- R_1 is the sum of the ranks in the mentioned sample;

Similarly, the statistic variable U_2 was calculated for the sample interviewed after the implementation of intervention X. The smallest value of U_1 and U_2 was used for consulting the significance tables and performing the Wilcoxon test.

3.4 Study area: the car sharing service of Enna city

The analysed area focuses on the municipality of Enna characterised by the presence of 27.000 inhabitants and around 5300 students from two universities respectively Kore University of Enna (about 4800 enrolled) and Dunarea de Jos Galati (about 500 enrolled) in 2020. The city is distributed along three macro areas called Enna Alta, Enna Bassa and Pergusa (Figure 2).

The road infrastructures are mostly classified by local roads without preferential lanes. At present there is no bike sharing service but since 2019 a car sharing service has been activated by the company titled Amat Palermo. The service is provided from 06:00 to 22:30 on weekdays and from 07:00 to 23:00 on holidays every 30 minutes. In April 2019 the city inaugurated a car sharing service with the presence of 6 cars and a minivan.

There are two bus terminals located respectively in Enna Alta and one in Enna Bassa near the universities. There is a taxi service little used by residents due to the high costs.

The Kore University of Enna is located in the centre of Enna Bassa and the surrounding areas are populated by residential neighbourhoods mostly inhabited by university students and commercial activities such as shops and supermarkets (Figure 3). The majority of the student population is commuting while the remaining part has rented, or owned houses scattered in the three ones defined above.

AmiGO is the car sharing service in the Sicilian Region, supplementing public and private transport, intelligent, economic and respectful of the environment. In Enna it has been started for less than a year and provides for the facilitation of travel to and from the areas of the historic centre where many primary schools, banks and offices are located, Enna Bassa, a place of schools and universities and the tourist area of Pergusa (Figure 4). The service is intended as an alternative to use of the private vehicles and provides for the sharing of a car park with low environmental impact among all the registered citizens, limiting the use of the car to the time strictly necessary.

4 Results and discussion

4.1 Statistical analysis results

From May 2018 to January 2020, five investigation campaigns were launched, which involved the paper and online administration of a total of 704 surveys. The investigated population was entirely related to the Kore University with a gender distribution of 48 % males and 52 % females with an average age between 24 and 29 years (63 %).

After the first part of the survey, related to socio-demographic analysis, the possible itineraries made by the university students for home/school and home/leisure reasons were monitored, considering the location of the different houses and the location of each Faculty of the University of Enna Kore. It has been estimated

Figure 2 *Enna landscape and an overview of Enna Alta, Bassa and Pergusa*

Figure 3 *An overview of Enna Bassa where the University of Enna Kore and relative distribution of each Faculty*

Figure 4 *Dedicated AmiGo parking area and car sharing service in Enna*

that around 62% of the population lives in the district of university faculties located in Enna Bassa (within 1 km), 32% in Enna Alta (considering also cities with similar distance) and 6% in Pergusa. The latter two are respectively 5 km and over 6 km away from the university area.

The geo-localisation of the University of Enna Kore is barycentric with respect to the area of Enna Bassa and the three districts that characterise it are about 700 m from each other. Students are uniformly distributed in the various faculties, i.e. 51% of students attend the Faculty of Psychology and Sociology, 25% attend Engineering and Architecture courses, while the remaining 28% are divided between economics and law studies.

The second part of the questionnaire focused on the driving licence possession and on the use of alternative transport modes, i.e. the frequency of public transport or the propensity to go on foot. In particular, a high percentage of students have a driving licence (over 98% and 51% for over five years). However, a good percentage of them use public transport (41%) or walk (26%) to go to university. Considering home/leisure itinerary, the percentage of car use increases (43%) because the public transport service is active until 10 pm. It is impossible to reach Enna Alta and Bassa on foot due to the high slope and the absence of pavements on many road sections. The third part of the questionnaire allowed to acquire information on the previous experience of the car sharing service (47% in Italy and 26% abroad) and therefore studied the propensity to use it (72% of students thought it very useful to set up a car sharing service).

A part of the sample (about 10% of the entire sample randomly selected) was doubly interviewed and on the completed questionnaires it was possible to implement a before and after analysis. The aggregate results of the individual attributes show almost total interest in the provision of a car sharing system dedicated to students and this result is consistent with those obtained for the attributes relating to the previous experience of car sharing services and willingness to pay for use of this service, distinguishing between low (65 %), medium (28%) and high (7%) rates. This corresponds to use of the small two-seater vehicles in the first case and small vehicles in the second. These choices are supported by Enna's morphology referring to the narrow streets of the historic centre.

4.2 Bivariate analysis results

In order to schematically summarise the obtained results, the Cronbach alpha and the chi-square values for each studied correlation are shown in Table 2. It emerged that in most cases the items are highly

Table 2 *Bivariate attributes and correlations between main and secondary variables*

Correlation	αCronbach	χ^2	p < .01	p < .05	p < .001
C1- 1	0.7691	17.8043	Sign	Sign	Sign
C1- 2	0.6125	13.3779	Sign	Sign	Sign
C1- 3	α < 0.3	6.6885	.0352	Sign	Sign
C2- 1	0.4 < α <0.6	12.8139	Sign	Sign	Sign
C2- 2	0.8467	27.6656	Sign	Sign	Sign
C2- 3	0.6762	11.4428	.0220	Sign	Sign
C2- 4	0.7795	9.1079	.0584	.0584	Sign
C2- 5	α < 0.3	64.6379	Sign	Sign	Sign
C2- 6	0.8194	15.5678	Sign	Sign	Sign
C2- 7	0.6771	17.6167	Sign	Sign	Sign
C3- 1	0.4 < α <0.6	7.56	.02282	Sign	Sign
C3- 2	0.7504	2.5099	.6428	.6428	.6428
C3- 3	0.4 < α <0.6	23.7965	Sign	Sign	Sign
C3- 4	0.4 < α <0.6	32.4531	Sign	Sign	Sign
C3- 5	0.8309	12.6495	Sign	Sign	Sign
C3- 6	0.6645	4.4359	.1088	.1088	.1088
C3- 7	0.7081	14.6545	Sign	Sign	Sign

correlated with each other, as there is a high internal consistency having obtained Cronbach alpha values higher than 0.60, which represent a good level of consistency. In some correlations, the range of variation is between 0.4 and 0.6 and this indicates a tentative and possible consistency. Therefore, it is possible to affirm that each question makes a real contribution to the measure of the construct.

However, the Cronbach alpha represents an indicator to measure the reliability and verify the reproducibility over time. Thus, in the cases of values from 0.4 downwards, this indicates that these correlations are not reproducible over time under the same conditions. The lower reliability in the case study was verified for the correlations corresponding to place of residence (distance) with car ownership. In fact, the results may vary over time if, for example, the user no longer owns a car or vice versa buys a new one. A similar phenomenon was also observed in the case of the correlation between car sharing utility and mode of transport for home/leisure, because evidently it is the shared mode of travel that is more considered by the examined users to go to school or work. Furthermore, since it is a large sample of students, not having a high financial availability, it is possible that they prefer to travel by private car (own or family car) or walking. In particular, in Enna Bassa, the entertainment venues are almost all close to the student residences.

The obtained results for the chi-square are discussed for each analysed main variable.

4.2.1 Place of residence (distance)

The first correlations were referred to the place of residence, which is likely related to the distance travelled during the daily trips. In this case, the city macro-areas and the neighbourhoods were grouped into three categories: a short-travelled distance (i.e. Santa Lucia; Ferrante and Enna Bassa); a medium-travelled distance (i.e. Monte; Lombardia and Enna Alta) and a long-travelled distance (i.e. Pergusa and other locations). It was considered useful to correlate this variable with the transport modes, both for home-school trips and home-leisure trips, in order to understand which mode is chosen by students according to the travelled distance. In addition, car ownership was also taken into account. By analysing the tables of contingency for each of these correlations, it was possible to observe that over 63% of students travel for a short distance, but they were almost equally distributed among the three considered modes, that is, walking, public and private transport. For longer distances, a very small percentage of students walking was obtained; however, those who use the bus were more than double compared to those who use the private car. This denotes good sustainable travel behaviour. Slightly different considerations were found in the case of home/leisure trips: in fact, a good percentage of walkability was registered, equal to 31% of the total; however, at the same time, an increase in the number of trips by car was noted to the detriment of those made by bus. This is consistent with the fact that greater flexibility is required for home-leisure trips, but this also indicates a lack of public transport service to support demand mobility. Finally, it was observed that the number of trips for short, medium and long distances was very similar both in the case of car ownership and no-ownership.

The results associated with the bivariate analysis, with respect to this first main variable, were coherent for the three correlations and allowed to assume

a hypothesis of independence between the variables, except in the case of the last correlation, for which there is a dependency at $p < 0.01$ (see Table 3).

4.2.2 Car sharing utility

Evaluation of propensity to join the car sharing was assessed in the opinion of students about the utility associated with the service. Students expressed a rating on a Likert scale from 1 to 5 based on how useful a car sharing service dedicated to Enna's students can be. The analysed correlations with this main variable took into account different aspects relating to socio-demographic data; travel behaviour and car sharing experience.

For the examined sample, equally distributed between men and women, it was not observed a specific propensity for car sharing based on gender. In general, the students' opinions regarding the usefulness of a car sharing service were very positive. The maximum value of 5 was selected in more than 70% of cases and for this reason it was chosen to analyse correlations considering the utility values from 3 to 5. Non-car owners showed a greater propensity towards car sharing, attributing a higher utility rating. The distance also influenced car sharing service, which was deemed proportionally useful up to 4 times more in the case of medium distances than the short ones. As regards the transport modes used for daily trips, higher utility values associated with car sharing were obtained by those who walk, especially in the case of home-leisure trips, which need more flexibility. Through the calculation of the chi-square, a dependence from the variables of a distance and transport mode was found (for $p < 0.01$ and $p < 0.05$) and so they influence reciprocally with the main variable. Finally, any previous experience of using car sharing was taken into consideration, both in Italy and abroad. Certainly, a positive aspect was represented by the fact that almost 50% of the interviewed sample had already used a car sharing service. This percentage rises in the case of experiences abroad. However, the same utility values were also attributed by those who have not yet experienced this service.

4.2.3 Rate selection

The last analysed main variable was the rate selected by students for car sharing service, which in a certain way is representative of the willingness to pay to use this service. The correlations taken into consideration were similar and the influence that the utility, associated with the car sharing service, may have on the willingness to pay a certain rate, was assessed, as well.

The rate was set in three different ranges (i.e. low, medium and high), depending on the service characteristics and on operational attributes (for example the displacement of the vehicle used, the type of power supply, etc.). Considering that, for all the correlations the highest percentage of responses was concentrated in correspondence with the low rate values. It emerged that women were more willing to pay an eventual medium rate to use the service. Analysing the correlation with the distance, from the calculated table of contingency it was possible to observe that as the travel distance increases, the willingness to pay a higher rate decreases, because the total cost of the service is greater due to the increasing number of kilometres. As regards the attribute linked to travel behaviour, represented by the transport mode, it was registered as a willingness to pay a medium rate one third less than a low rate by students travelling by car; for those who walk, this percentage is only reduced by half. In addition, in this case, the willingness to pay for using a car sharing service was demonstrated in the same way by students without previous experience of using car sharing. In the end, from the last correlation it clearly emerged that utilities with a value of 5 were associated with higher percentages of potential increases of the rate, since the utility associated with the car sharing is greater and, therefore, they are willing to pay more.

4.3 Before and after analysis results

A selected group was interviewed the first time before the implementation of car sharing in Enna and the second time after a period of approximately one year after the activation of the service. The before and after analysis (B/A) was based on the comparison of data obtained by dispensing the questionnaire both before and after the car sharing service implementation in Enna (mentioned in the methodology section as intervention "X").

The Wilcoxon test was performed considering the three variables related to: (i) the car sharing utility; (ii) the willingness to pay and thus the rate of the service; (iii) the recommendation of the car sharing service. The results of the statistical test are reported in Table 3.

Since the test proves non-significance, then it can be argued that the null hypothesis cannot be rejected. This implies that the randomly selected values of the items associated to the population interviewed before the implementation of the car sharing service is assumed to be equal to the randomly selected values of the items associated to the population interviewed after implementing the intervention.

The results indicate a measure of how similar the random sample is and how close it is to the entire population. Therefore, the judgments of the considered sub-sample, both before and after the implementation of the service, remain almost similar considering the three examined variables. In fact, the students interviewed have shown that they tend to use alternative and less polluting forms of mobility regardless of the

Table 3 *Wilcoxon test results*

Items	p-value	Z	p < .01	p < .05	p < .10
Utility	0.06619	-1.8371	Not Sign	Not Sign	Not Sign
Rate	0.127	1.5259	Not Sign	Not Sign	Not Sign
Recommendation	0.272	-1.0984	Not Sign	Not Sign	Not Sign

Table 4 *Percentage variation of B/A analysis and criteria evaluation*

B/A variables	Percentage variation %	Criteria
Place of residence	11	Travel distance
mode of transport for home / school	14	Sustainability
mode of transport for home / leisure	2	Sustainability
Bus use frequency	0	Sustainability
Car sharing experience in Italy	0	Increasing experience
Car sharing experience abroad	5	Increasing experience
Electric/hybrid vehicle experience	4	Technological Innovation
Propensity to use electric/hybrid vehicles	0	Technological Innovation
Car Sharing utility	11	Willingness
Car sharing reservation methods	0	Innovation
Main reason for using car sharing	2	Motivation Convenience
Rate selection	16	Willingness to pay
Service subscription	8	Customer; Loyalty

implementation of these shared service types. This evidence could be partly attributed to the fact that there is a widespread participation in dissemination campaigns and surveys regarding shared mobility. Furthermore, even the preventive planning actions by the local government in the context of SUMPs can trigger the propensity to use these forms of mobility [45].

With regard to the B/A analysis, almost all of the significant variables reported in the investigation were subject to the B/A analysis and specifically the percentage of response variation was calculated. This percentage was compared to a judgement criterion associated with each variable, so as to be able to assign a negative or positive judgement to the variation, from a multiple perspective. Table 4 shows the results of the B/A analysis highlighting the aspects and variables most sensitive to the introduction of the car sharing service in Enna:

As regards the place of residence, there was a total variation of 11%. The real appreciable variation of this variable, if analysed with respect to the "travel distance" criteria, can be reduced to 3% since the other residence displacements concerned the two neighbourhoods of Ferrante and Santa Lucia, which are quite close between them and therefore comparable. Therefore, no major changes from this point of view are appreciable.

Another significant variable related-to the mode of transport, both for home/school and home/leisure daily trips. In this case, an overall variation of 14% was obtained. In detail, for home/school 7% stopped using the bus and started walking and 3% changed mode of transport from private car to bus, while the remaining percentage started using the car or the bus instead of walking. Considering the sustainability criteria, a positive variation of this variable can be assumed. With reference to home/leisure trips, a positive percentage variation of 2% was obtained. No variation was obtained with respect to the bus use frequency.

Evaluating the sharing mobility experience, the percentage variation related to car sharing experience in Italy is zero, but considering experience abroad it was registered an increase of 5%, which represents a positive aspect as this could lead to a greater propensity to use the car sharing service implemented at Enna.

Concerning the experience of using electric or hybrid vehicles, there was registered an increase of 4% in favour of these new innovative forms of alimentation. No variation was observed relating to the willingness to use an electric or hybrid car sharing service.

An important aspect is represented by the value associated with the usefulness of a dedicated university car sharing service.

As a matter of fact, by comparing the answers obtained before and after the implementation of the car sharing service in Enna, there was a response percentage variation equal to 11%. This would seem to suggest that student opinion has changed. However, this can be denied because analysing in detail the answers, it was a variation of the utility judgement, which varied between the values of 4 and 5 on the Likert scale. In fact, there was a 5% variation from value 5 to value 4 and a 6% from 4 to 5. So, it can be said that

there was no change in thinking of students that could affect the willingness to use the car sharing service. Moreover, the preferred way of reservation represented for the majority by the use of an APP has not undergone changes. Instead, only 2% of response variation was registered in the motivation to use car sharing. In this case, this variation derives from a change in the convenience of using car sharing, first associated with flexibility and subsequently with an economic aspect. Therefore, it was possible to attribute a slightly negative judgement, as the economic aspect is prevailing the idea of the availability of a vehicle that allows you to move more flexibly, instead of owning a car. This consideration was also found in the subsequent significant variable analysed, that was the rate selection for car sharing service. The total percentage variation is equal to 16% and specifically 13% corresponds to a declaration of intent to pay less, moving from a high to medium rate, or from medium to low rate. This negatively affects the willingness to pay for the car sharing service.

In a certain way, a similar consideration made for the car sharing can be associated with the variable linked to the kind of typology service subscription to car sharing. In fact, the response variation of 8% can be considered null as the number of students who expressed a preference for non-subscription is the same as the number that expressed a change in favour of activating a subscription.

A final consideration that can be made in relation to this B/A analysis is that, by performing a cross-observation of the response variation before and after the implementation of car sharing and of the experience related to amiGO, half of these observed variations derived from users of the service. Therefore, any kind of recorded change is only partially attributable to a direct experience of the car sharing service.

5 Conclusion

Car sharing services play an active role in keeping congestion at bay by meeting the current short-term demand for private cars. As long as people have the possibility to share a car, they will be more likely to continue using the public transport in the future. Therefore, it is important to analyse how certain factors increased or decreased the propensity to use car sharing in the pre-pandemic phase in order to understand the correlation between the variables analysed and those arising from the pandemic and to be able to optimise the service.

This work was focused on evaluating the implementation of a car sharing service in the city of Enna, involving students through a large consultation survey featuring mixed data from Internet/paper surveys. The results made it possible to analyse students' propensity to use the shared mobility and to provide an opinion on the current car sharing service implemented by the Municipality of Enna in collaboration with a transport company. A detailed analysis was performed, segmenting the sample, in order to study the heterogeneity of preferences and model the propensity to the car sharing.

The data processing took place through a bivariate statistical analysis and through a before and after method on a portion of the sample investigated. The Cronbach alpha computation was used in order to measure the internal reliability of the questionnaire. Then, the chi-square test was calculated to analyse different combinations of attributes and their correlations. Different combinations of the socio-demographic parameters, experience with shared mobility and the propensity to use a university car sharing service have been taken into consideration. Moreover, a non-parametric test (i.e. Wilcoxon test) was performed and through the B/A analysis it was possible to investigate the judgement of the student population regarding the service implemented in Enna.

Based on the research on the transfer model of the optimization of the future car sharing service implemented in Enna, this document has reached the following conclusions:

- a lack of public transport service to support mobility demand can generate a greater propensity to use private cars for daily trips, especially in the case of home-leisure trips, which need more flexibility. In this context, a car sharing service could help to make the journeys more sustainable, without necessity to own a car;
- despite having carried out an extensive investigation campaign, there seems to be no high gender influence in the analysed correlations. However, it would be interesting to deepen this aspect with reference to other case studies;
- previous experiences of using car sharing can influence a greater propensity to join this service. Since the analysed sample is represented by students (high percentage of 18-30 years old), it is possible to affirm that a young age group tends to be more willing to try a new experience, in this case a shared mobility service;
- the highest percentage of responses was concentrated in correspondence with the low rate values associated with car sharing services. It would be interesting to investigate the willingness to pay with reference to the service characteristics and on operational attributes. Furthermore, to encourage the use of car sharing, it would be useful to propose discounted rates for students, also depending on the travelled distance.

The analysis conducted and the selection of the variables analysed allowed evaluation of possible correlations and mutual influences, paving the way for recalibrating the implemented service. It also lays the groundwork for future phases of the research that

will consider multiple simultaneous correlations with a multinomial logit analysis. The obtained results from this research highlight some of the factors that optimise the propensity to use car sharing by the student population in the area examined. These results can be implemented and optimised by investigating more variables or by comparing different target groups such as millennials. This approach allows to highlight that the motivation for a stable participation (for a longer period of time) and the collaboration of the user samples is essential to obtain useful results in the process of service optimisation. Through this strategy and the related survey steps both experts and non-experts represent different and often complementary perspectives. The research findings could also be useful for local authorities, university managers and managers of shared mobility services to control the part of the travel demand.

Data availability statement

Some or all data, models, or code generated or used during the study are available from the corresponding authors by request.

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