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# University propensity assessment to car sharing services using mixed survey data: the Italian case study of Enna city

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**Abstract**

The sustainable development of urban areas, characterized by the expansion of university centers, can benefit from car sharing services, expanding the potential of public transport, especially when the population is almost represented by off-side students and commuters. This work focuses on the investigation of a set of attributes able to interpret and measure the propensity of students to join car sharing. The paper provides a discussion about the potential implementation of a car sharing service, particularly referring to the case of Enna (Italy), where university students constitute a significant percentage of residents. Students have been involved via a wide consultation survey and the analysis was conducted by using mixed Internet/paper survey data. The propensity was modelled in applying the Likert Scale and a chi-squared test was calculated to check the difference between expected and observed frequencies for several combinations of the analyzed attributes. Results are useful to understand their heterogeneous preferences and to define the way for a well-thought-out design of a new shared transport service.



*Keywords:* Sharing economy, Propensity to car sharing, Sustainable transport systems

## 1. Introduction

The unwanted environmental consequences of fossil energy consumption have raised interest in sustainable and environmental alternatives for a wide range of application domains (Ketter et al., 2016; Noppers et al., 2014). Specifically, transport efforts are growing up considering new engine technologies and to stimulate the acceptance of

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novel shared transportation modes to reduce the environmental impacts of transportation in everyday life. The term shared mobility refers to a variety of transportation modes that are shared on an as-needed basis (Shaheen et al., 2016). Traditional forms of shared mobility are of course taxis, car rentals and public transport (Sprei, 2018). Currently, new business models and concepts are spreading. A dominant development of these newer forms of shared mobility is one-way carsharing or free floating carsharing where users do not need to return the car to the starting point (Wielinski et al., 2015). While in traditional carsharing systems users usually return the car to the place where they picked it up, some companies, mainly in major cities, have installed systems where users are allowed to leave the car at defined places ("one-way"), sometimes even at any free parking space within a certain area ("free floating") (Firnkorn and Müller, 2015).

Car sharing services hold great promise for sustainability and individual mobility alike. Studies estimate that a single shared car can replace between nine and thirteen private cars (Martin et al., 2010), given that a private car is primarily used for a mere 5% of the time (Ballús-Armet et al., 2014). Moreover, car sharing services can complement public transportation, particularly in providing mobility services in those trips which are typically only suited for car driving (De Lorimier and El- Geneidy, 2013), reducing the need to have private cars and increasing the access to mobility to many. Therefore, car sharing combines positive elements of both private and public transportation, making it attractive to a significant percentage of population, especially younger people who do not own a car (Efthymiou and Antoniou, 2016), because it allows to access and use cars without the need to actually purchase them (Martin et al., 2010).

Based on this premise, the sustainable development of urban areas, characterized by the expansion of university centers, can benefit from such shared transport system expanding the potential of public transport, especially when the student population is almost represented by off-side students or commuters. The characteristics of potential users of this system have been investigated in this research in order to maximize its effectiveness. This paper focuses on the investigation of a set of attributes able to interpret and model the propensity of university students to join car sharing. Mixed data collected from Internet and paper surveys have been used to understand early adopters' preferences for this shared transport service and to evaluate a possible subsequent expansion to the whole population of the monitored area.

The remainder of the paper is divided into five sections. Section 2 will provide a discussion about the acceptance of car sharing and related implications. Section 3 will describe the main steps of the methodology, based on the survey method (3.1), the survey design (3.2) and the model development (3.3). Section 4 will introduce the case study with the description of the analyzed areas (4.1) and data analysis (4.2), while Section 5 will show and discuss the main results of analyzed attributes correlations. Finally, Section 6 will conclude by summarizing the research findings.

## 2. Acceptance of car sharing and its implications

Car sharing services have gained momentum as a potential alternative to various transport modes in the early 90s and the number of carsharing members is estimated to be approximately 1.7 million in 27 countries (Steinberg and Vlasic, 2013). It combines the positive characteristics of public transport and car, but it also attracts bike users and people travelling on foot. Carsharing implies several advantages for society, such as a reduction in car ownership due to members getting rid of their cars or avoiding purchasing one in the first place (Giesel and Nobis, 2016; Martin and Shaheen, 2016; Wappelhorst et al., 2014). In addition, there are indications that carsharing members drive less after becoming member of a carsharing organization, i.e. the vehicle-kilometers travelled are reduced (Martin et al., 2010). A comprehensive exploration of the impacts on car sharing travel behavior was made in Switzerland (Muheim e Reinhardt, 1999). In a survey, respondents were asked to report their travel behavior before and after the implementation of the car-sharing service, basing it on the inaccurate estimate of the mileage covered by a private car and what they would have traveled by car-sharing. Among the benefits of using car sharing, there is also a reduction in consumption compared to private vehicles, thus reducing the environmental impact (Steer Davies Gleave, 2017). Considering it, some studies predicted a significant reduction in car ownership and CO2 emissions (Firnkorn eMüller, 2011) from free-floating car-sharing. Nevertheless, the actual impact seems to be more complex, as car owners do not reduce the bike, walk and public transport trips, but instead start using cars (shared) (Firnkorn, 2012). Some of the first empirical data were published by the (Seattle Department of Transportation, 2014), citing

the results of a survey among Car2go members. The results indicate a rather reduced reduction in the domestic vehicle. A related approach carried out in Switzerland produced similar results (Becker et al., 2017). Ohta et al. (2013) conducted a web-based survey to investigate the acceptance of carsharing and eco-cars, showing that provide factual information about the widespread acceptance of eco-cars positively affected the acceptance of this new type of low-emission vehicles; although non-car owners had the greatest acceptance of car sharing and eco-cars.

Nowadays, car sharing can rely on several consolidated projects. Most of the existing projects have highlighted that users' socio-economic characteristics and geographical context of each city play a major role in a successful implementation and growth of any car sharing program (Burkhart and Millard-Ball, 2006; Shaheen and Cohen, 2007; Shaheen et al., 2004). Most of studies on car sharing are primarily focused on the feasibility of car sharing programs and the impact of carsharing on auto ownership and vehicle usage (De Luca and Di Pace, 2014). However, some studies looked into mobility patterns and socio-demographic variables and how they correlate with interest in or stated willingness to participate in carsharing. Several authors (Efthymiou et al., 2013; Hinkeldein et al., 2015) found a greater interest in adhering to car sharing by those whose mobility patterns do not rely so much on personal car use. A similar correlation is presented considering those more satisfied with public transport (Wang et al., 2017; Mugion et al., 2018). In other studies, a high interest in car sharing options is shown by people living in city centres, men and younger people (Prieto et al., 2017; Cartenì et al., 2016).

In this context, the demographic characteristics of car sharing users represent an important aspect to investigate, taking into consideration that the composition of the car sharing members differs from city to city (Efthymiou and Antoniou, 2016). Thus, the variability of carsharing users' travel patterns and the need to understand the factors that determine their decision to join, maintains the research interest around this subject high. This paper extends the current literature and contributes in this direction by proposing a procedure to investigate university students' preferences and measure their propensity to join car sharing from a multiple criteria point of view.

## 3. Methodology

### *3.1. Survey method*

There are several studies in the literature that have addressed the analysis of car-sharing propensity, using different procedures of acquiring user demand data. In general, a widespread method for collecting quantitative data on individual travel behavior are surveys, which capture all activities and journeys during a predefined survey period in accordance with Becker et al. (2018). Since individual travel behavior varies over the course of a week, the travel diary should ideally cover several days to take this variation into account. In the literature, several authors show that this method is characterized by the collection of inaccurate and missing data (Bricka and Bhat, 1972; Stopher et al., 2007). The most recent alternative that promises to reduce these effects is the use of ITS technologies (Torrisi et al., 2017, Torrisi et al., 2018), through smartphone-based geolocation by users. However, due to the novelty of smartphone-based systems, only a few the investigations have already employed them (Wargelin et al., 2012; Oliveira et al., 2011; Cottrill et al., 2013; Kopp et al., 2015).

The proposed study sees the involvement of a large sample of students, with the aim of modeling their propensity in adhering to a car sharing system. The analysis was conducted by using collected data from both on-line and papers questionnaires, since on-line questionnaires alone may be vulnerable to biases because the respondents usually tend to be more positive in their responses (Dillman et al., 2009). Furthermore, respondents to on-line questionnaires are often represented by a young age group, but this paper focuses on students (high percentage of 18-30 years old), and so both datasets can be considered consistent. The analysis also involved students with random characteristics of travel pattern, so as leading to a good classified sample.

### *3.2. Survey design*

The interpretation of the real choice process of carsharing, as an alternative mode to travel, was characterized by three phases: the acquisition of information about the transport system; the development of interest in the system and finally the choice based on the service characteristics. The paper survey was filled by individual interviews that

were performed at University premises during annual student meetings; while the on-line survey was developed in Google forms and was disseminated via mailing lists and social media.

The questionnaire was created by defining three sections. The first part was related to socio-demographic data (e.g. age, gender; municipality of residence; attended faculty). The second section included questions about the current travel patterns of the students (e.g. car driving license possession; car ownership; predominant transport mode used for home-school trips and social activities; weekly frequency of trips). The third section focuses on the knowledge of car sharing service and the propensity to use it, by proposing questions related to specific characteristics about the vehicles (e.g. electric, hybrid) and their operation (previous national and foreign experiences of car sharing; way of reservation; fare).

### *3.3. Model development*

The propensity was modelled in applying the Likert Scale and a chi-squared test of independence was calculated to check the difference between expected and observed frequencies for the socio-economic and instrumental attributes of analysis (i.e. gender, age, car ownership, driver license seniority, weekly frequency of trips, experiences of using car sharing, fare of the service and type of subscription, etc.) and for several of their combinations.

The rating system of Likert scale (Likert, 1932; Louviere et al., 1999) 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 subject's perception.

To test the association between two categorical variables where the distribution of one varies according to the values of the other, it was calculated the mean score $X_i$ for each attribute category (Eq. 1):

$$X_i = \frac{([1*x_{i1}]+[2*x_{i2}]+[....]+[n*x_{in}])}{\sum_1^n x_{in}} \quad (1)$$

where $i$ is the single category of the considered attribute; $x_i$ is the value associated to each measure and $n$ is the number of measures for each category. The overall mean score associated with all categories $X_{overall}$ was likewise calculated. Then, the difference between observed and expected frequencies was assessed by using the statistical test $\chi^2$ as shown in the following equation (Eq. 2):

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad (2)$$

where $O$ is the observed cell frequency, E is the expected cell frequency and $\sum$ is the sum of cells in the table of values associated to each category of the considered attributes. The chi-square test shows whether the differences from the expected report they are due to the case or if they are real differences. First it is needed to establish the Hypothesis "Nothing" ($H_0$). This hypothesis assumes that there is no real difference between observed values and expected values. Using eq (2), which contains the chi-square formula, it is necessary to determine whether to accept the hypothesis nothing (differences due to chance) or if to refuse it (real differences). Therefore, under null hypothesis, there is no association between the two variables. Thus, is the value of $\chi^2$ is large, that means a large difference between the observed and the expected values, the data would not support the null hypothesis, and vice versa.

## 4. Case study

### *4.1. Territorial framework*

The study was conducted in the city of Enna, a mountainous area located in the center of Sicily, with a population of about 8000 units. The urban area is characterized by three macro-areas: the historical area of Enna Alta, the residential area of Enna Bassa, where the universities, the hospital and many commercial activities are located and the recreational area around Lake Pergusa.

The public transport has 5 lines from 7 a.m. to 10 p.m. but it is characterized by a low frequency. The city has never had a car sharing service to support urban connections. The figure below (Fig. 1) shows the location of the investigated areas and the distances between the various university complexes.

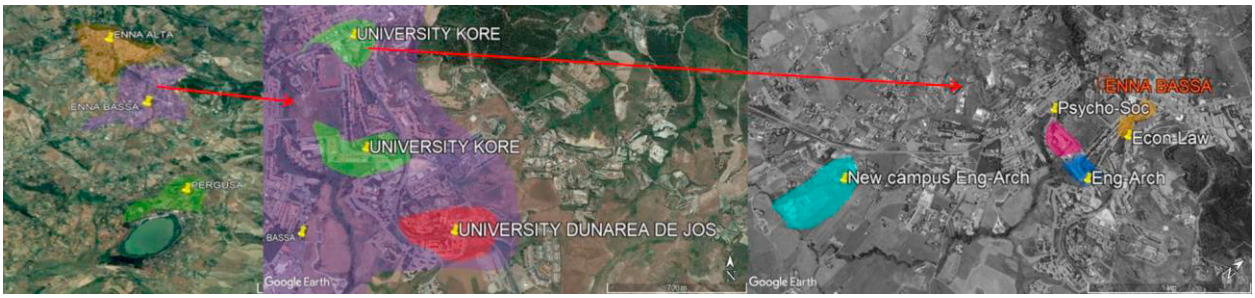


Fig. 1. Monitored area and Faculties localization

### *4.2. Student questionnaires and data analysis*

Students have been involved via a wide consultation survey that was performed at University Kore of Enna, during annual student meetings. In a period of five months (May to September 2018 for the first survey campaign and from December 2018 to January 2019 for the second one) a total of 550 completed questionnaires were collected (436 paper and 114 electronic questionnaires). Respondents from the first and second wave needed an average of 20 minutes to complete the paper survey while those on the web took about 16 minutes. With this rather short investigation time, the fatigue effects that cause a response bias have been reduced to a minimum.

The sample consisted of undergraduate and postgraduate university students enrolled in different courses (7% of the entire student population), well matched with 46% of men and 54% of women, and 60% of which with an average age between 24 and 29 years.

From the first part of the questionnaire it was deduced that 55% of the investigated population lives in the neighbourhood of university faculties located in Enna Bassa (within a 1 km radius), 34% in Enna Alta (also considering towns with similar distance) and 11% in Pergusa. These last two are respectively 5 km and over 6 km away from the university area. It is necessary to underline that the University Kore of Enna is located in the central area of Enna Bassa and the three complexes that characterize it are about 700 m from each other. Students are evenly distributed in the different faculties, 40% of students attend the faculty of Psychology and Sociology, 25% of them attend Engineering and Architecture courses while the remaining 35% is divided between Economics and Law studies. The second part of the questionnaire allowed to understand the travel patterns of the students, both by private and public transport and on foot. Particularly, a high percentage of students have the car driver license (more than 95% percentage and 67% of them for more than five years). However, a fair percentage of them use public transport (39%) or walk (28%) to go to university. For home-leisure trips, the percentage of car use increases (40%) because the public transport operates up 10:00 p.m. and also due to the high slope and the absence of sidewalk from Enna Bassa to Enna Alta. The third part of the questionnaire allowed to acquire information on previous experience of the car sharing service (46% in Italy and 27% abroad) and therefore investigated the propensity to use it (79% of students consider it useful to set up a car sharing service). Aggregated results of individual attributes show an almost total interest in the provision of a car sharing system dedicated to students and this result is consistent with the ones obtained for attributes related to previous experience of car sharing services and availability to pay for using such service, distinguishing among low (65%), medium (28%) and high (7%) fare. This corresponds to the use of small two-seater vehicles in the first case and small cars in the second one. These choices are supported by the morphology of Enna referred to narrow streets that characterize the Old Town.

## 5. Results

In order to assess the transport service to be implemented in the study area, preliminary evaluations have been performed on statistical dependency/independence of surveys results. After evaluating the aforementioned variables, the correlations between some of these attributes were analyzed, as listed below:

- gender with way of reservation;
- car ownership with car sharing rate
- years of car driving license possession with car sharing experience abroad.

The values in brackets are those of the expected type, while those in bold are those observed (Table 1).

Table 1. Expected values and Observed values for the three analyzed correlations

| *First correlation analysis* | | |
|---|---|---|
| | *Way of reservation* | |
| *Gender* | with subscription | without subscription |
| male | **184** (195,58) | **126** (114,42) |
| female | **163** (151,42) | **77** (88,58) |

| *Second correlation analysis* | | | |
|---|---|---|---|
| *Car* | *Car sharing rate* | | |
| *ownership* | low | medium | high |
| Yes | **122** (136,15) | **88** (78,88) | **22** (16,87) |
| No | **201**(186,75) | **99** (108,12) | **18** (23,13) |

| *Third correlation analysis* | | | | |
|---|---|---|---|---|
| | *Years of car driving possession* | | | |
| *Car sharing experience* | other | 1<year<4 | 4<year<5 | >5 |
| Abroad | **11** (3,21) | **42** (37,42) | **45** (47,84) | **49** (58,53) |
| National | **1** (8,79) | **98** (102,58) | **134** (131,16) | **170** (160,47) |

The analyzed correlations are characterized by three different degrees of freedom. Their evaluation allows us to understand how, as the degrees of freedom vary, for the acquired variables there can be dependence or independence between them. The calculation of the statistics of $\chi^2$ allows to identify how much the observed data diverge from those we estimated under the independence hypothesis. If the value is low, reality and theory will come very close; if the value is high, they deviate from each other. And if reality is very close to the theory ($\chi^2$ low), since the theoretical hypothesis is that the two variables are independent of each other, we will conclude that the two variables do not influence each other reciprocally. While if $\chi^2$ is high, it is not possible to affirm that the variables are independent, but they influence each other. The data obtained from these correlations with multi-degree of freedom reflect what is described by literature in terms of relationship between degrees of freedom and p-value in accordance with Miller and Siegmund (1982).

In the first correlation the chi-square statistic is 4.25 and the p-value is 0.039. The result is significant at $p < 0.05$. In this case, since there are two degrees of freedom, calculated considering (number of rows-1)*(number of columns -1) and a value lower than 5.99 is shown, it is possible to affirm that there is a correlation between the variable linked to gender and the presence of a possible subscription for the use of car-sharing. The second correlation is characterized by a chi-square statistic of 7.09 and a p-value of 0.028. The result is significant at $p < 0.05$. In this case, the variables linked to car sharing rate and the car ownership affect the statistical evaluation, considering that the value of chi-square is slightly lower than the probability value correlated to 2 degrees of freedom. The result is significant at $p < 0.001$ for the third correlation analysis, with a chi-square statistic is 28.95.

## 6. Conclusion

This work focused on the potential implementation of a car sharing service in the city of Enna, by involving students via a wide consultation survey characterized by mixed Internet/paper survey data. The relevant aspects of this work are represented by an analysis of the car sharing propensity explicitly investigated based on a specific population segment (i.e. university students); and also by the fact that it is possible to draw some useful insights to support decision makers in the realization of the service.

Detailed analysis has been performed, by segmenting the sample, so to investigate preference heterogeneity and modelling the propensity to car sharing. Chi-squared test has been calculated to analyze several combinations of attributes and their correlation (e.g. previous experiences of car sharing service with the willingness to pay to use it).

These results can give an idea of what students perceive as most important for designing a new shared transport service in their city, making understand how potential customers need to be taken into consideration to promote a renewed interested in the sharing mobility and to develop measures to stimulate car sharing services in society.

Further analysis will be carried out in the future phases of the research, analyzing the results of the tasks of choosing hypothetical scenarios, based on instrumental attributes (i.e. price, parking convenience and car type) in order to obtain more information on the structures of preference, identifying a true ranking of preferences and paving the way for a well-thought-out design of a new shared transport service.

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