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School Bike Sharing Program: will it Succeed?

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Abstract

Encouraging active and sustainable transport modes in order to limit the excessive use of cars, as well as reducing pollutant emissions and creating livable urban environments, has become one of the priorities for policymakers in recent years. The introduction of innovative systems increasingly being introduced in modern cities, such as bike sharing, can certainly contribute to the spread of cycling and thus allow a radical change in the mobility habits of their citizens. This can be especially true for high-school students who are often otherwise accompanied by their parents with private cars. This article aims to assess the influence that a bike sharing program for students has on modal share and on city mobility. As a case study, the city of Palermo was chosen, where the use of the car for home-school trips is prevalent. The "Go2School" project, which involves the creation of a bike sharing program for four schools, with the construction of cycle docks and cycle paths in the nearby areas, will soon become a reality. Thanks to appropriate surveys and questionnaires, a multinomial logit model was calibrated to estimate the modal share towards bike sharing for the students and evaluate the demand for this transport mode.

Keywords: bike sharing; shared mobility; transport demand.

1. Introduction

Physical activity is recognized as an important element of a healthy lifestyle, since it reduces the risk of illness and premature death. The modern lifestyle, with its dependence on the car, sedentary activities and automation of some activities at home and in the workplace, has led to a worrying increase in obesity, depression and cardio-

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vascular diseases. According to ISTAT data in Italy, the proportion of the population aged 18 and over with excess weight is 45.9% (35.5% overweight, 10.4% obese), while 23 million 85 thousand people (39.2% of the population aged 3 and over) declare that they do not engage in sports or physical activity in their free time. Adolescents are not immune to the consequences of a sedentary lifestyle, so much so that in Italy 24.7% of people aged between 6 and 17 are overweight or obese. One of the interventions that policymakers can put into place to counteract this problem is to encourage active modes of transport, i.e. pedestrian and cycle mobility, especially for transit between home and school or home and work. Furthermore, a more widespread use of these transport modes would benefit pollution reduction and urban mobility. The excessive and often indiscriminate use of the private car in the city has, in fact, had a series of negative consequences on the liveability of the urban environment, such as congestion, land consumption, noise and atmospheric pollution, and accidents.

The creation of an urban environment suitable for cyclists and pedestrians is, therefore, one of the main objectives of the most recent urban planning approaches, such as the Transit Oriented Development (TOD). This planning approach, created to counter the phenomenon of urban spread, provides for the creation of livable neighborhoods, where the presence of different activities (shops, schools, restaurants, offices, residences, etc.), is designed to guide the demand for transport as much as possible towards public transport and active modes (on foot and by bike). Indeed, the introduction of cycle paths and bike sharing systems in TOD areas contributes to reducing the number of private cars circulating, to reducing road congestion and emissions (Zhang and Mi, 2018), to increasing accessibility, to creating flexible mobility, to improving the health of citizens through exercise, and to supporting multimodal connections and intermodality with public transport.

The introduction of bike sharing programs is certainly one of the most incisive actions to promote and encourage the use of bicycles in the city. The aim of this paper is to investigate on the students' attitude to use a bike sharing service following the implementation of a specific school program, in order to investigate the possible changes in mobility habits of students, i.e. the modal split towards cycling mobility. Some high schools of the city of Palermo have been chosen as case study, where the Go2School project is taking place.

2. Background

The choice to make bike trips is influenced by several factors (Muhs and Clifton, 2015). First of all, the quality of the cycling infrastructure is important, since there is a greater propensity to use the bicycle where there is a network that has continuity and cycle paths are well delineated and separated from road traffic. In addition, the decision to cycle is influenced by the availability of bicycle-parking spaces, changing rooms and showers in the workplace or places of study, the absence of obstacles in cycle lanes, the number of traffic lights, the volume and speed of vehicles that travel the adjacent streets, the number of turning movements and the resulting conflicts.

Therefore, these factors are not only linked to accessibility, but above all are related to security. For underage students, safety becomes a determining factor in their propensity to make the home-school trips with their own bicycle or taking advantage of a bike sharing service, since they are still subject to the will of their parents, who often view to these transport modes as high risk. The safety of home-school routes must therefore be taken into consideration for the success of a bike sharing program. It is important to note that safety is not only referred to the separation of the cycle traffic from other vehicular traffic or to the absence of obstacles on the cycle paths but also to the sense of security that the urban environment transmits, in relation to architectural degradation and crime (Stewart et al., 2012).

The analyses carried out have lead us to determine that the size of the family, the type of school attended by the children, the professional status of the parents, the presence of other people (grandparents, relatives, friends), disposable income (possibility to pay a baby sitter) and the availability of more than one family car, all play a role in the choice of how to get children to school (McDonald, 2008).

Mattson and Godavarthy (2017) have reviewed the studies that identify the other factors which determine the success of bike sharing programs. These factors include the presence of schools and university campuses, parks and recreational areas, the topography of the territory, the weather (low temperatures, snow, rain, high humidity and strong winds diminish the propensity to use bike sharing (Gebhart and Noland, 2014)), the proximity of bike parks to railway stations and stops of local public transport as well as the walkability of neighborhoods (Faghih-Imani et al., 2014).

Moro et al. (2018) have instead identified all those factors that are barriers to the success of a bike-sharing service, classifying them in organizational obstacles, referable to the difficulties of the company that manages the service, regulatory obstacles (lack of regulation and incentive policies) and cultural barriers (resistance of citizens to change their mobility habits).

Even the location and configuration of the new cycle paths become determining factors as they not only influence accessibility but also influence the choice to use the bike sharing service due to the different perception of the safety of the home-school journey. Furthermore, the construction of the cycle paths influences the other modes of transport in a more or less decisive way, since the space required for them is often removed from road traffic, reducing the space available for cars and motorcycles. The method used to determine demand for the sharing service, therefore, takes all these factors into account.

3. The Go2School project

The Go2School project has been promoted and implemented by the Municipality of Palermo, AMAT Palermo SpA - the municipal company that carries out public transport services by bus and tram, and that also manages a car sharing service - the University of Palermo and four public schools (Liceo Scientifico Albert Einstein, Liceo Linguistico Statale Ninni Cassarà, Istituto Tecnico Vittorio Emanuele III, Istituto Tecnico Commerciale Pio la Torre). It consists of making a special bike sharing service devoted to students and school staff, via subscriptions and bike parking marked with the initiative's logo throughout the territory, as well as new cycle docks and new cycle paths near the schools.

There will also be the introduction of a large fleet of bicycles, some of which will be two-seater bikes, in order to encourage socialization among who will use this service. With this type of bicycle it will also be possible to pursue another important goal at a social level, i.e. to allow the use of the bike also for visually impaired or blind people on their journey from home to school.

AMAT will also produce a digital "Go2School" platform for mobile devices, which will allow users to plan routes and create crews for daily home-to-school travel.

The Go2School initiative is part of a mobility context where car use is dominant over other modes of transport. Cycling is a mode of transport that is used very little in Palermo, even by students, for which it could instead be a valid alternative. Cycling and bike sharing offer several advantages, such as a low cost, zero impact on the environment, and flexibility. Moreover, the city of Palermo, because of its topography and favorable climate, has a high potential for increasing the use of the bicycle.

The current cycle network extends for about 47 km and is made up of cycle track, cycle lanes on the sidewalk or cycle lanes shared with buses. The cycle network has no continuity: cyclists, therefore, have the possibility of circulating on cycle tracks not adequately connected to each other only for short journeys, being then forced to move among motorized vehicles; this condition is a serious threat for safety.

4. The bike sharing service in Palermo

The Go2School bike sharing program will be integrated with the bike sharing service that is currently active in the city of Palermo, which is managed by AMAT Palermo S.p.A.. Since AMAT is a company linked to the municipal administration, using incentive strategies for innovative mobility services in synergy with political action is therefore easier.

The implementation of the bike sharing system, called BiciPA, took place in 2016 through co-financing by the Ministry of the Environment. The service has about 2360 subscribers and in 2017 had a fleet of 210 bicycles.

Bike sharing is offered as a station-based mode, so users can pick up and drop bicycles off in 37 bicycle parks located within the municipal area. The annual subscription cost is 25 euros and the rental cost is linked to the time of use. The first 30 minutes are free, which makes this service desirable for short trips, as these are usually home-school trips. Sixty percent of subscribers use the service for less than an hour a day. The service is integrated with the car sharing system - a unique case in Italy - as it is possible to use the two services using the same subscription card, at a cost of 35 euros.

The bike sharing program for schools will therefore be an extension of the current service: for the Go2School

network the existing infrastructural and technological system will be exploited and some of the existing bike sharing docks will be exploited. Moreover a subscription to BiciPa will be provided for students who wants to use the bike sharing service even outside school hours and the Go2School bikes can be used by all citizens outside school hours, when they will be reserved only for students and teachers of the four schools.

5. The questionnaire

The model has been calibrated in experimental way for these four schools on the basis of some questionnaires, realized for the Go2School project by the Department of Economics, Business and Statistics of the University of Palermo and by the students of the Liceo Scientifico Einstein.

The total number of the interviewed students is 1131, 754 of which are males and 377 are females. The most represented school is ITI Vittorio Emanuele III with 416 students (Tab. 1). The questionnaire made it possible to learn about the mobility habits of students with regards to home-school trip and the willingness to ride a bike. In particular, it was found that only 1.8% of students routinely use the bicycle (Fig. 1) and that the absence of cycle paths – i.e. the sense of unsafety - is the main reason (19%) for which students do not use this mode of transport for their home-school trips.

It is possible to notice that most of the home-to-school trips are made on foot (21.6%) and by car (20%), then by the bus (9%). Car is chosen by many people because the public transportation service is often perceived by the students as time-consuming.

Table 1. Number of students interviewed for the Go2School project.

School	Student interviewed	Total students	Sampling fraction
ITET Pio La Torre	227	938	24.2 %
ITI Vittorio Emanuele III	416	1521	27.4 %
LLinguistico Cassarà	190	606	31.4 %
LScientifico Einstein	298	834	35.7 %
Total	1131	3899	29.0 %

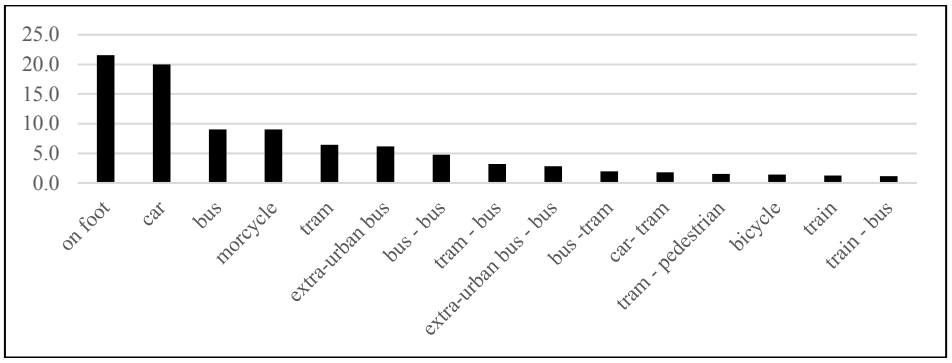

Fig. 1. Modes of transport used by students (%).

Table 2 shows the percentages relative to the students' willingness to use the new bike sharing service.

It is possible to observe how the majority of students declare themselves in favor of using the bike sharing service, while a slightly lower percentage expresses doubts about this service, probably for reasons related to safety, distance from school or other factors. The students aged fourteen and the female students are much less inclined to use this service.

This data assumes that students show a strong interest in this bike sharing program for schools, which could therefore effectively act as a driving force for promoting cycling. The answers provided by the students have been used in the random utility model for the simulation of modal choice behaviors.

Table 2. Students' attitude to use the new bike sharing service (ROW %).

School	Yes	Under certain conditions	No
ITET Pio La Torre	38,80	49,80%	11,40%
ITI Vittorio Emanuele III	52,40	38,00%	9,60%
L. Linguistico Cassarà	40,00%	51,60%	8,40%
L. Scientifico Einstein	49,30%	42,00%	8,70%
Total	46,80%	43,70%	9,50%

6. The model

In order to determine the bike sharing potential demand, a simulation model as the multinomial logit has been used. Through these models it is possible to quantify, for a given scenario, the probability that the user chooses a specific mode of transport and to evaluate the modal share. The user attributes a utility, or in the case of the model in question, a disutility, that is a cost to be faced, to every transport mode, and, since we assume that the user is a rational decision maker, he will most likely choose the mode that minimizes his costs. Five different transport modes have been considered: private cars (as passengers), public transport (urban buses, extra-urban buses, train and tram), pedestrian mobility, motorcycles and bike sharing. The construction of the model has been started with the creation of an Excel worksheet, in which the following data have been reported:

1. the identification number of the interviewee, which is an integer repeated for the five available modal alternatives;
2. the address of the interviewee, necessary for the evaluation of home-school travel times for each mode of travel, obtained from the questionnaire;
3. the means available to make the journey home-school, in which the following modes of transport have been reported with numbers 1 to 5: 1 - pedestrian movement; 2 - bicycle; 3 - motorcycle; 4 - car; 5 - Local Public Transport (TPL);
4. the mode of transport chosen by the individual interviewee, in which the number corresponding to the modal choice adopted is reported;
5. a binary variable, or "dummy" variable, which is 1 for the choice made by the respondent and zero for the remaining alternatives;
6. travel time in minutes to complete the journey home-school with all the modal alternatives available;
7. alternative specific constants for the bicycle, for the motorcycles, for the car and for public transport;
8. an attribute relating to the presence of newly built cycle lanes, which is also a binary variable that is 0 for cycle path not present and 1 otherwise;
9. an attribute relating to the presence of new Go2School bike sharing stations of future construction, which is also a binary variable that is 0 (station does not exist) or 1 (station built);
10. the age of the interviewee;
11. the gender of the interviewee (0 - male; 1 - female).

For each Origin-Destination pair - the origin is identified by the address of the student's home reported in the questionnaire and the destination from the address of the attended school - it has been necessary to derive the times for the five modal alternatives. The length of the routes on foot have been obtained using Google Maps, as well as the travel time by car, taking into account the level of congestion on the morning rush hour. In order to calculate the walking time for each O-D pair, a speed of 0.6 m/s has been assigned to pedestrians; it should have been assigned a speed of around 1.2 m/s but it has been preferred to halve this value in order to attribute a certain disutility to on foot trips. For determining travel times, a speed of 10 km/h has been assigned to travel by bicycle, while an average speed of 20 km/h for residents of Palermo and 45 km/h for residents in neighboring municipalities has been considered for motorcycles. With regard to travel by public transport, the overall time has been assessed according to the following formula:

$$t_{public\ transport} = 2 \cdot t_{on\ foot} + \alpha \cdot t_{waiting} + t_{on\ board} \quad (1)$$

in which $\alpha = 1$ for trams, train, high frequency urban bus services and extra-urban buses, since the service regularity is good, while $\alpha = 4$ for urban buses with low frequency. In addition, in the cases in which the bus passes through the terminus along the journey home-school, an additional 5 minutes have been added to consider the waste of time at the terminus. The travel time by public transport has been obtained using the web site of the public transport companies.

The model takes into account the intermodality of bike sharing with the public transport network. The intermodality between cycling and public transport must, in fact, be absolutely incentivized in order to ensure that urban mobility benefits in terms of reducing the use of private cars. It is possible to take the bike on trams and on trains, and stations could become points of aggregation of the demand for cycling: students who live at a remarkable distance from the school can take advantage of the rail transport to arrive at the nearest station to the institute, and then continue the trip with the bicycle, owned or shared. Therefore the model considers the possibility that cycling is used for last mile journeys. Through the STATA software the behavioral modal choice model has been calibrated. The first calibration has found that some variables are not statistically significant, having a p-value higher than the threshold of 0.05. Therefore a stepwise regression method has been applied in order to eliminate all the variables having a poor predictive contribution. In particular, a stepwise regression with backward elimination has been adopted: starting from the complete model, all the variables that have not statistical significance have been eliminated. This allows, therefore, to have a new calibration not influenced by non-significant variables. Considering the significant variables obtained, the utility for the different modes of transport are the following:

$$t_{on\ foot} = \beta_t \cdot t_{on\ foot} \quad (2)$$

$$V_{bike} = \beta_t \cdot t_{bike} + \beta_{c.i} \cdot Cycle\ Infrastructure + \beta_{gender\ bike} \cdot Gender + \beta_{ASA\ bike} \cdot ASA_{bike} \quad (3)$$

$$V_{motorcycle} = \beta_t \cdot t_{motorcycle} + \beta_{age\ motorcycle} \cdot Age + \beta_{ASA\ motorcycle} \cdot ASA_{motorcycle} \quad (4)$$

$$V_{car} = \beta_t \cdot t_{car} + \beta_{age\ car} \cdot Age + \beta_{gender\ car} \cdot Gender \quad (5)$$

$$V_{public\ transport} = \beta_t \cdot t_{public\ transport} \quad (6)$$

The results of the calibration are shown in Tab. 3. The variable "Time" is the one-way trip travel time between the origin zone to destination, different for each mode of transport. "ASA_{bike}" and "$ASA_{motorcycle}$" are the alternative specific constants for the bicycle and the motorcycle. "Cycle infrastructure" is the attribute relating to the presence of new cycle paths in the O-D trip. "$Age_{motorcycle}$" and "Age_{car}" are the age of the interviewee for the motorcycle alternative and the car alternative. "$Gender_{bike}$" and "$Gender_{car}$" are the gender of the interviewee for the bicycle option and the car option.

Table 3. Calibration results with STATA

Significant variables	Coeff. β	Stand. Error	z	p-value	[95% Conf.	Interval]
Time	-0.0281359	0.0015991	-17.59	0.000	-0.0312701	-0.0250016
ASA_{bike}	-4.207812	0.2711247	-15.52	0.000	-4.739207	-3.676418
$ASA_{motorcycle}$	-7.522429	1.092619	-6.88	0.000	-9.663922	-5.380935
Cycle infrastructure	4.432648	0.2717114	16.31	0.000	3.900103	4.965192
$Age_{motorcycle}$	0.2930129	0.0683109	4.29	0.000	0.1591259	0.4268998
Age_{car}	-0.160138	0.0083377	-19.21	0.000	-0.1764797	-0.1437963
$Gender_{bike}$	-0.4138	0.1513262	-2.73	0.006	-0.7103939	-0.1172062
$Gender_{car}$	1.047189	0.1371263	7.64	0.000	0.778426	1.315951
Number of observations = 9225;		Number of cases = 1845;		Log likelihood = -2099.8466;		
Wald chi2(8) = 1034.54;		Prob > chi2 = 0.0000.				

7. Results and discussion

The results obtained are all extremely significant and the coefficients have the correct sign. The time coefficient is, in fact, negative, as the user perceives a decrease in the usefulness of the alternative chosen as the travel time increases. A single coefficient has been assigned to the variable "Time", independently of the modal alternative. The alternative specific constants for bicycles and motorcycles are very negative, which is also correct because these modes are associated with an intrinsic dangerousness of the vehicle. The coefficient of the variable "Cycle infrastructure" is, on the other hand, very positive: this is a fundamental aspect because it shows how, in the presence of a safe cycle infrastructure, the user associates a high utility with bike. The coefficient of the variable "$Age_{motorcycle}$" is positive, which means that the more the age of the student increases, the more he will choose to move with the bike, coherently with reality; the coefficient for the variable "Age_{car}" is negative and this is consistent with reality because the more young the student is, the more likely he will be accompanied by parents by car. The coefficients associated with the variables "$Gender_{bike}$" and "$Gender_{car}$" are respectively negative and positive. Since in the database the value 0 was associated with the males and the value 1 with the females, this means that the bicycle is preferred more by the males, while the females are more inclined to be accompanied by car. This is also consistent with studies in the literature, such as that of McDonald (2008).

From the utility expressions (2)-(6) the mode choice probabilities can be obtained for each mode of transport and each O/D pair. It was decided to differentiate the case of urban journeys from that of extra-urban journeys. Therefore, we first considered the O/D pairs related to the urban environment, considering those students who can make home-to-school travel on foot within 90 minutes (about 3 km). The results are reported in Tab. 4 for the current situation and the future scenario, in which the new bike sharing service dedicated to students has been introduced and the cycle trucks around the schools have been created.

In this case, the model overestimates the number of public transport users. This overestimation is mainly due to the unreliability of the Palermo public transport service, perceived by school students.

The change in the modal choice by the students in favor of the shared bicycle is decidedly interesting, if the possibility of traveling along safe cycle paths is guaranteed. In the current situation in which the lacking state of the cycle infrastructure is present, the percentage of students traveling by bicycle is around 2%, while with the introduction of the new bike sharing service the percentage would increase enormously, reaching 51%. This result shows that the students, in the presence of an effective bike sharing service and of a safe route to school, could modify their mobility habits in favor of the shared bicycle.

Table 4. Summary table of the results obtained for the current scenario and for the future scenario (time on foot < 90 minutes).

Mode of transport [%]	Current scenario	Model prediction for current scenario	Future scenario	Model prediction for future scenario
On foot	44.4	41.4	22.4	20.3
Bicycle	2.4	1.1	53.6	50.9
Motorcycle	9.2	7.0	4.9	3.2
Car	21.4	16.2	11.5	8.1
Public Transport	22.6	34.4	7.7	17.5

The same analysis has been repeated for all students who can walk the home-school route in a time exceeding 90 minutes (about 3 km). The results for the current situation and for the future scenario are shown in Tab. 5.

In this case, the model underestimates the public transport users with respect to the real situation, especially in favor of the "motorcycle" and "car" alternatives. However, it can be assumed that this is due to the fact that many of the students who live outside Palermo have as their only modal alternative the public transport service consisting of extra-urban buses or the train, not being able to be accompanied by the parents. This consideration can explain why the model, which cannot foresee the constraints in the choices of the students, slightly overestimates the mode choice probabilities for motorcycle and car. The result obtained for the cycling modal share indicates that a large number of students, while living at a considerable distance from schools, are inclined to change their current mode

of transport by opting for the bike sharing service, with an overall percentage of choice that leaps from 1% relative to the current scenario to 48% in the future. The bicycle acts in this case not alone for the entire journey but, instead, in perfect integration with the public transport service.

It can therefore be said that the implementation of the "Go2School" bike sharing program for schools, with the creation of new and safer cycling infrastructures, can contribute significantly to the promotion of cycling mobility among students.

Table 5. Summary table of the results obtained for the current scenario and for the future scenario (time on foot > 90 minutes).

Mode of transport [%]	Current scenario	Model prediction for current scenario	Future scenario	Model prediction for future scenario
On foot	0.2	5.7	0.0	2.1
Bicycle	0.4	1.3	51.3	48.5
Motorcycle	9.2	16.0	6.3	7.8
Car	23.9	34.0	15.3	17.2
Public Transport	66.2	43.1	27.1	24.4

8. Conclusion

The present paper aims to evaluate how initiatives such as the introduction of a bike sharing service specially designed for students can be favored by the students. The feeling of being part of a community, the ecological value of the initiative, the reduction of rush-hour traffic around schools, as well as the opportunity for meeting and socializing by making trips together, can make this service a good alternative to the use of private cars. The strength of our methodology is in considering multiple factors like the spatial location of the bike parking, the sense of safety and security associated with the home-school path, the quality of the cycle paths and the socio-economic characteristics of the users. The model calibrated for the city of Palermo has shown how the introduction of special bike sharing programs aimed at schools are effective in encouraging cycling. Future work will focus on distributing the questionnaire to other schools and also to other categories of users (teachers and school staff), on including in the model other modes of transport such as carsharing, investigating the integration with bike-sharing, and on improving the estimation of the public transport demand.

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