Cycling for Home-to-School Travel in Palermo: A Method for Assessing the Optimal Allocation of New Cycling Infrastructure

Gabriele D'Orso and Marco Migliore(✉)

Dept. of Engineering, University of Palermo,
Viale Delle Scienze Building 8, 90128 Palermo, Italy
{gabriele.dorso,marco.migliore}@unipa.it

Abstract. In order to reduce the number of cars on the road, one of the most incisive actions is to encourage cycling, e.g. through the introduction of bike-sharing systems. In particular, the activation of special bike-sharing programs for school students could lead students to choose this mode of transport to make their own home-school travel. The success of such initiatives is primarily linked to the presence of a continuous and functional cycle network, which can create safe routes to school. It is, therefore, necessary a cycle network design model that allows determining the optimal allocation of new cycle paths, maximizing the number of users and considering technical and economic constraints. As a case study, the city of Palermo has been chosen; in fact, the Go2School project, a bike-sharing initiative aimed at students of four high schools, has been launched in Palermo.

Keywords: Cycling · Active transportation · Safe routes to school · Bike sharing · Network design problem

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 cardiovascular 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, 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

© Springer Nature Switzerland AG 2019
S. Misra et al. (Eds.): ICCSA 2019, LNCS 11620, pp. 217–230, 2019.
https://doi.org/10.1007/978-3-030-24296-1_19

series of negative consequences on the liveability of the urban environment, such as congestion, land consumption, noise and atmospheric pollution, and accidents.

As a transport mode, cycling has predictable travel times, continuous availability, easily maintained routes and non-emission of pollutants, and it offers a relaxing and healthy exercise. Therefore, the design of the city has effects on the inactivity of the population - the World Health Organization also affirms it - and having neighborhoods designed for pedestrians and cyclists means putting the citizen in a position to practice physical activity [9, 19]. For many people, in fact, the most acceptable form of physical activity is the one embodied in everyday life, such as walking or cycling, instead of using the car. Therefore, in order to counteract inactivity and decrease the health costs that derive from it, the administrations, which until now have underestimated the problem and have not considered it in their decision-making processes, should make interventions that promote cycling and make it a safe, convenient and attractive way to do our daily errands [8].

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, like the Transit Oriented Development (TOD) approach. This urban planning approach, created to counter the phenomenon of urban diffusion, provides for the creation of livable neighborhoods, where there are different activities (shops, schools, restaurants, offices, residences, etc.), designed to guide the transport demand as much as possible towards public transport and active modes (on foot and cycling). The introduction of cycle paths and bike sharing systems in urban areas contributes to reducing the number of private cars circulating, to reducing road congestion and emissions [23], 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, offering a possible solution to the first/last mile problem.

Nowadays urban planners and engineers are starting to pay more attention to the role that walking and cycling have to play in urban mobility. This can be seen in the adoption, by many cities, of Sustainable Urban Mobility Plans, which include pedestrianization, downsizing of roadways in favor of pedestrian and cycling space, limitations of vehicle speeds and introduction of 30 km/h zones, in the creation of safe routes to school and in the construction of new infrastructures dedicated to bicycles and pedestrians. For example, Copenhagen is a model to be followed in the context of incentive policies for the use of bicycles and in the construction of infrastructures such as pedestrian bridges and cycle paths. New attention is also evident in the diffusion and success of many applications for smartphones that seek to encourage walking and promote an active lifestyle through the reward mechanism (e.g. the Empower project, funded by the European Union) [3].

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 implement a methodology that allows determining the optimal location of new cycle paths in order to maximize the demand attracted by a bike-sharing service designed for schools. As a case study, the city of Palermo has been chosen, where the Go2School project is taking place. The project is promoted and implemented by the Municipality of Palermo, AMAT Palermo SpA, 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 available to students 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.

2 Background

The choice for cycling is influenced by several factors [18]. 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. The extension of the cycle network and its quality have a greater impact on the use of bike sharing systems, than the creation of new cycle paths, which also increase the accessibility of the service [22]. 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 [21]. The analyses carried out have lead us to determine that the size of the family, the type of school attended by the students, 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 students to school [14].

Mattson e Godavarthy [13] 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 [10]), the proximity of bike parks to railway stations and stops of local public transport as well as the walkability of neighborhoods [7]. Moro et al. [17] 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 becomes a determining factor as it not only influences accessibility but also influences the choice to use the

bike sharing service due to the different perception of the safety of the home-school journey. Very often the deliberate choice not to cycle is caused by the configuration of the road, and in particular by the conflict that occurs when a road has different functions and the danger that arises when it is used by different categories of users. 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. In Europe, many experiences have shown, however, how the redesign of the roads, through a different distribution of spaces, can ensure that the different components of traffic (motorized vehicles, cyclists and pedestrians) can coexist in safety, reducing the severity and number of accidents.

Some scholars have developed models useful for the design of cycling routes. Lin and Yu [12] have developed a bikeway network design model for cycling in urban areas which has the objectives of minimizing cyclists risk, maximizing comfort, maximizing service coverage for residents and minimizing the impact of the bikeway on road traffic, considering at the same time the network continuity, the monetary budget and the bikeway types as constraints. Dondi et al. [4] proposed as a design tool the approach of the Contest Sensitive Design, which involves all stakeholders in the development of the cycle facilities and an interdisciplinary approach in identifying the best design solution.

Caggiani et al. [2] have implemented an urban bikeway network design model, which consists of an objective function that minimizes the inequalities between different groups of users, in terms of accessibility to cycle paths.

3 The Bike-Sharing Service in Palermo

A bike sharing service is currently active in the city of Palermo, which is managed by AMAT Palermo S.p.A., the municipal company that carries out public transport services by bus and tram, and also manages a car-sharing service. Since AMAT is a company linked to the municipal administration, adopting strategies for encouraging shared 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 Italian Ministry of the Environment. The service has about 2360 subscribers and in 2018 had a fleet of 400 bicycles, 210 of which are already available for users. BiciPA is a station-based service, so users can pick up and drop bicycles off in 37 bicycle parks located within the municipal area (Fig. 1). 7 new cycle docks are being installed by the company, in order to extend the service to areas and trip attractors not yet served. The annual subscription cost is 25 euros and the rental cost is linked to the time of use. The first 30 min 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 both services using the same subscription card, at a cost of 35 euros.

The Go2School program for students is therefore an extension of the current bike-sharing service.

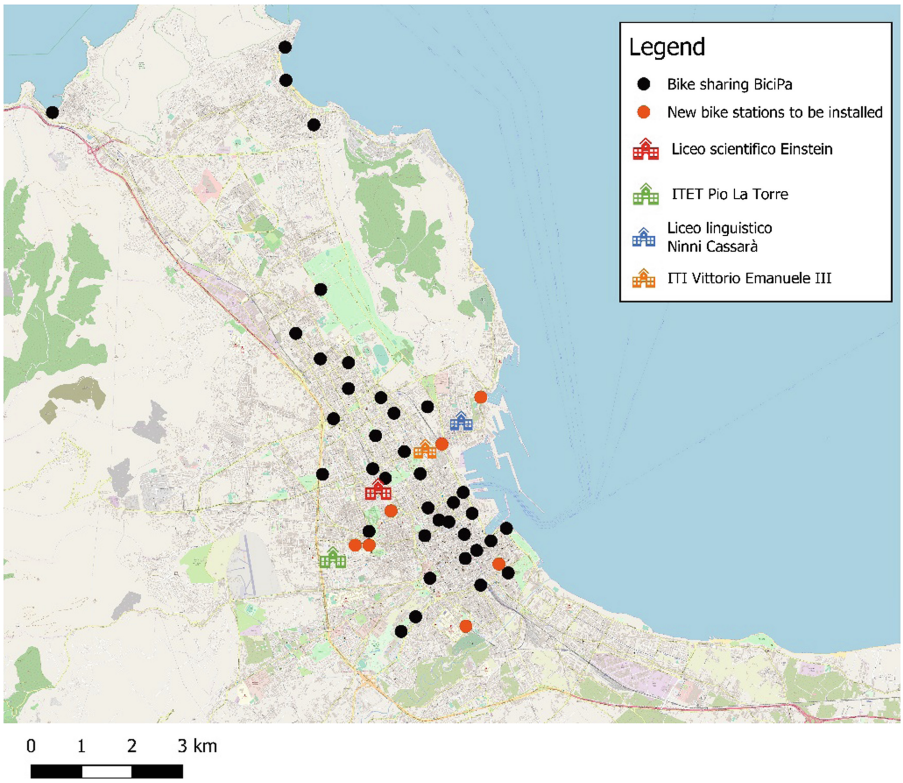


Fig. 1. BiciPa cycle docks in Palermo.

4 Cycling in Italy and in Palermo

The Go2School initiative is part of a mobility context where car use is dominant over other modes of transport. In Italy, there are about 625 cars per 1000 inhabitants and only one out of two Italians owns a bicycle. Italy is, therefore, very far from other European countries, like Netherlands, which has 481 cars per 1000 inhabitants and 1.2 bikes per inhabitant. Approximately 51% of urban journeys are carried out in Utrecht by bike and around 48% in Amsterdam (Knowledge Institute for Mobility Policy, 2017). A comparison between the modal share in Italy [11] and in Netherlands [20] is presented in Table 1.

In Palermo, cycling mobility suffers even more than in other Italian cities. According to the ISTAT data (2011) of the Municipality of Palermo, 278,954 people commute daily; equal to 42.4% of the resident population. More specifically, 42.1% of daily trips (equal to 117,495 people) are made to reach the place of study, while 57.9% (equal to 161,459 people) are made to reach the workplace.

The most used mode of transport for systematic trips is the private car, both as a driver (33.4% of the total number of journeys) or as a passenger (17.4%). The motorcycle (motorbike, scooter, moped) follows, with 11.9%. An estimated 10.9% of

Table 1. Comparison between the modal share in Italy and in Netherlands (%).

Transport mode	Italy (2016)	Netherlands (2016)
Pedestrian	17.1	18
Bicycle	3.3	27
Car	64.5	47
Bus/tram/metro	4.4	3
Train	0.9	2
Other	8.9	3

trips are made by bus, 0.7% by private bus or school bus and 0.3% by train or by the urban railway. Only 1.4% of journeys are made by bicycle. Finally, 23.7% of journeys are made on foot. The motorization rate is high: there are 57 cars per 100 inhabitants.

There are differences between the trips made by the students and those made by others. To reach the place of study the largest number of trips is made on foot; 36% of the total. The most used vehicle is the private car (as a passenger), for 33.8% of journeys, followed by the bus (15.7%), the motorbike (7.5%) and for just 0.9% from the bicycle. Regarding the time taken to reach school, 57.1% of students take up to a quarter of an hour; 87.6% reach their destination within half an hour. From these data, we note that cycling is a mode of transport that is very little used in Palermo, even by students, for whom 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.

Furthermore, cycling is faster than other modes of transport for trips of up to 5 km [6]. Moreover, the city of Palermo, because of its topography and favorable climate, has a high potential for increasing the use of the bicycle.

5 The Italian Legislation About Cycling Infrastructure and the Cycle Network in Palermo

In order to illustrate the situation of the cycling infrastructure in Palermo, it is necessary to briefly introduce the current Italian legislation. The M.D. 557/1999 describes the types of cycle paths permitted in Italy. The cycle itineraries, located within the inhabited center or connecting to neighboring towns, can include the following types in descending order with respect to the safety they offer for the cycling users:

- cycle tracks;
- cycle lanes on a reserved lane;
- pedestrian and cycle promiscuous paths;
- vehicular and cycle promiscuous paths.

The cycle path can be realized:

- with a single or double direction cycle track, physically separated from vehicles and pedestrians with some sorts of vertical barrier;

– on a reserved lane in the roadway, with a single direction of travel, located on the right side of the roadway and marked with paint;
– on a reserved lane, obtained from the sidewalk, with a single or double direction, located on the side adjacent to the roadway.

The current cycle network in Palermo extends for about 44 km and consists of cycle tracks, cycle lanes on the sidewalk or cycle lanes in reserved lanes shared with buses (Fig. 2). The latter have the limit not to be well signaled to users, who do not recognize them as lanes for bicycles, and to be, moreover, traveled by buses, which stop and restart and have a different speed from that of bicycles, which increases the risk of accidents.

In 2015 the municipal administration has drawn up the Soft Mobility Plan determining the future cycle network, consisting of cycle paths that are safe, interconnected with other transport modes and accompanied by dedicated services and facilities. The planned network will have a total extension of 144.98 km (Fig. 3).

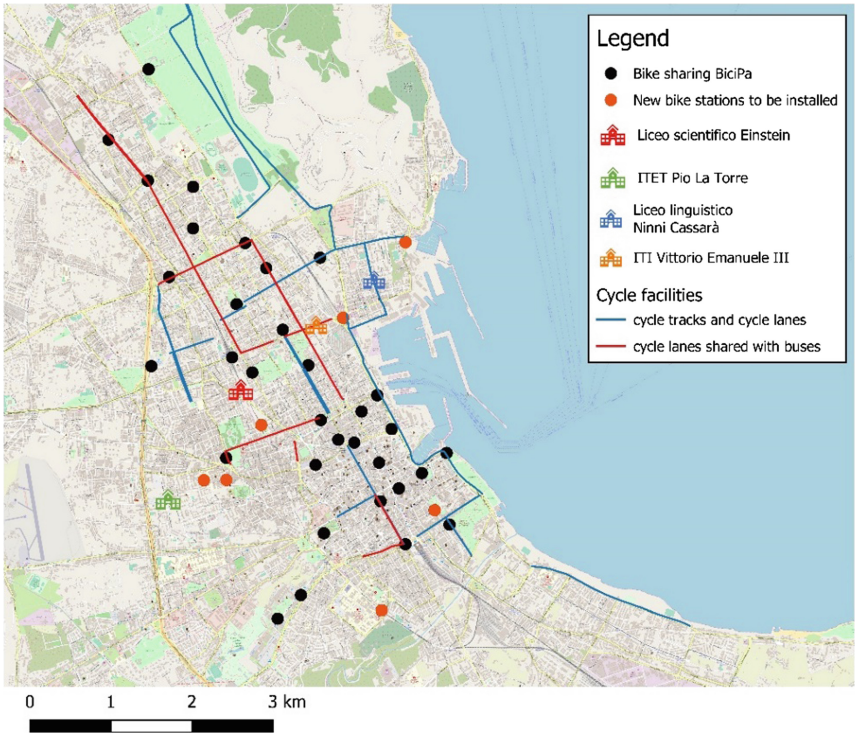


Fig. 2. Cycle facilities in Palermo.

Little has been done compared to the project. In fact, an obstacle in the construction of bicycle lanes is the old fabric of the city, characterized by narrow roads, especially in the old town, and by the on-street parking. The latter is an all-Italian problem,

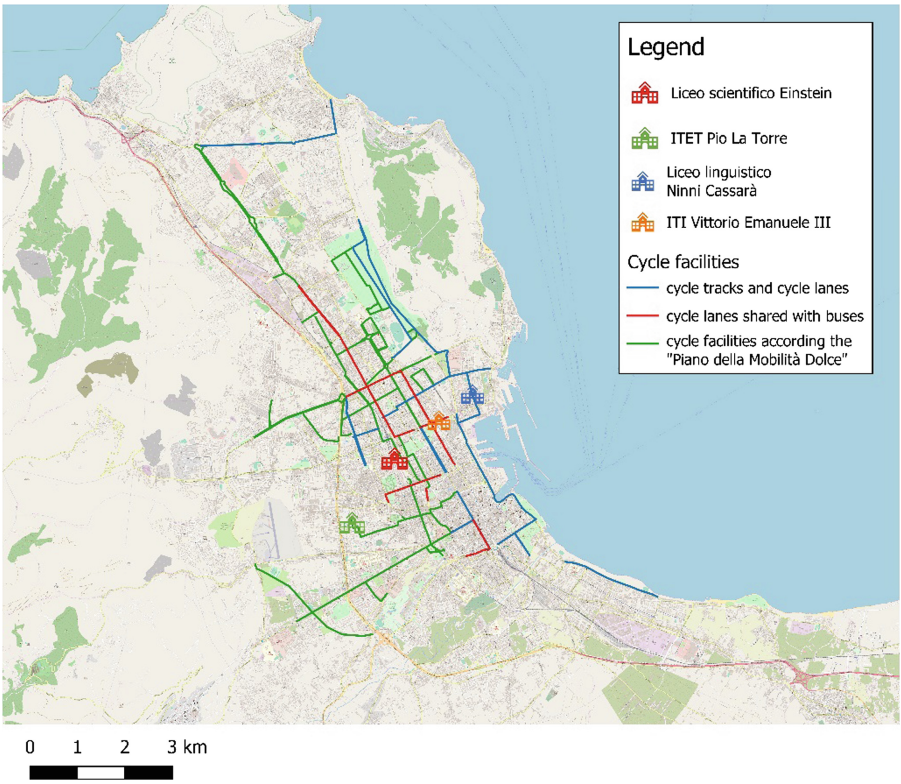


Fig. 3. The cycle network according to the Soft Mobility Plan.

considering that 56% of the parking spaces in Italy are on the road (European Parking Association, 2013), while in countries such as the Netherlands and Sweden on-road parking is less than 30% of the total parking space (respectively 28% and 20%).

6 The Methodology

A methodology has been developed for the proposal and the design of new cycling infrastructures. This methodology involves the following steps:

- calibration of a demand model;
- optimization process using an objective function in order to determine the optimal allocation of new cycling infrastructures;
- extension of the methodology to other schools; this is possible only by knowing the origins of home-school travel, i.e. students' residences.

The last step is necessary because the investment in the cycling infrastructure is justified only if there is an adequate demand.

6.1 Calibration of the Demand Model

For the case study of Palermo, the first step of the methodology has been described in a previous work [5]. For the Go2School project, an experimental demand analysis has been carried out, through which the probability that users choose cycling instead of other modal alternatives has been determined. The analysis has started with the administration of a questionnaire to a sample of students from the four schools. The total number of students interviewed is 1131; out of these, 754 are males and 377 are females. The most represented school is ITI Vittorio Emanuele III with 416 students (Table 2). The questionnaire made it possible to investigate the students' mobility habits regarding home-to-school trips and the willingness to cycle. In particular, only 1.8% of students routinely use the bicycle and the absence of cycle paths is the main reason (19%) for which students do not use this mode of transport for their home-to-school trips (Fig. 4).

Table 2. The sample for the Go2School project.

School	Number of interviewed students	Total students	Sampling fraction
ITET Pio La Torre	227	938	24,2%
ITI Vittorio Emanuele III	416	1521	27,4%
L.Linguistico Cassarà	190	606	31,4%
L.Scientifico Einstein	298	834	35,7%
Total	1131	3899	29,0%

The analysis leads to the estimation of the demand potentially attracted by the Go2School bike-sharing service thanks to the knowledge of the O/D paths and the application of a modal choice model. A demand model as the multinomial logit has been used. Through this model 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 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.

Starting from the results obtained with this analysis, the methodology provides that the cycle paths need to be built on the road axes in which the desire lines of the potential users are concentrated. If the cycle track overlaps with the desire lines of the user, the probability that cycling will be chosen as a mode of transport will increase since it is more responsive to the needs of the students.

Moreover, 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. According the model results, in the current situation in which the lacking state of the cycle infrastructure is present, the percentage of students traveling by

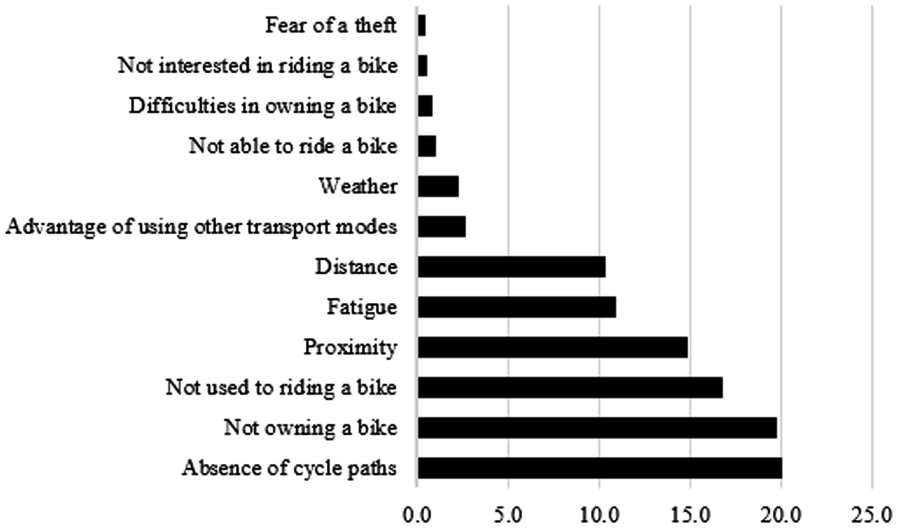


Fig. 4. Reasons why students don't ride a bike to school.

bicycle is around 2%, while with the introduction of the new bike-sharing service the percentage would increase enormously, reaching 52%. This result shows that the students could modify their mobility habits in favor of the shared bicycle if an effective bike-sharing service and a safe route to school exist. In the presence of a safe cycling infrastructure, in fact, the user associates a high utility with bike.

6.2 The Optimization Process

Starting from the analysis of some works about optimization problems [1, 15, 16] it was decided to formalize the problem of the cycle network design as an optimization problem considering an objective function for maximizing users' satisfaction subject to constraints. The optimization process takes into account the user satisfaction, the costs associated with investment in new cycling infrastructure and with management, the reduction of negative externalities (i.e. the reduction of atmospheric and acoustic pollution).

In the case in question, the analysis of modal share shows that many students switch from walking or public transport use to cycling; this causes the reduction of negative externalities to be limited. Since investment costs in cycle infrastructure are also limited, it was preferred not to include these factors in the optimization process, as there is a compensation between the investment costs and the benefits due to the reduction of externalities.

The optimal allocation of the new cycle infrastructures can be estimated by maximizing the objective function:

$$Argmax_{(x\in X)} = \sum_{od} d_{od}[ln\left(e^{V_{car}} + e^{V_{TPL}} + e^{V_{motorbike}} + e^{V_{bike}} + e^{V_{walking}}\right)_{cyclepaths} - ln\left(e^{V_{car}} + e^{V_{TPL}} + e^{V_{motorbike}} + e^{V_{bike}} + e^{V_{walking}}\right)_0]$$

subject to the constraints:

- X = vector of feasible cycle paths in the transport network taking into account the technical constraints
- $\underline{f}^{\star} = \underline{\underline{A}}\,\underline{\underline{P}}\left(\underline{C}\left(\underline{x}, \underline{f}^{\star}\right)\right)\underline{d}\left(\underline{x}, \underline{f}^{\star}\right)$

where:

- the users' "surplus" is expressed as the product of the total demand d_{od} and the variation in satisfaction between the project scenario and the initial one (without new cycle paths); the satisfaction has been calculated using the *logsum* function (user maximum perceived utility) for each origin-destination *o-d* pair (V_{car}, V_{TPL}, $V_{motorbike}$, V_{bike} and $V_{walking}$ are the car systematic utility function, the local public transport systematic utility function, the motorbike systematic utility function, the bike systematic utility function and the walking systematic utility function);
- the flow on each link of the network must be the solution of the fixed point problem depending from the interaction between the transport supply function and the transport demand function. In the last constraint $\underline{f}^{*}$ is the equilibrium flow vector, $\underline{x}$ is the cycle paths vector, $\underline{\underline{A}}$ is the incidence link-path matrix, $\underline{\underline{P}}$ is the path choice probability matrix, $\underline{d}$ is the demand vector.

By maximizing the surplus, it is possible to evaluate the cycle path that makes the O-D route safe for cyclists without wasting time for users who continue to move with other modes (in particular for cars and buses for which the travel time depends on the effective road width dedicated to vehicle flow).

The cycle paths set by the Soft Mobility Plan have been the starting point in evaluating possible proposals for the allocation of new cycle paths.

Furthermore, the methodology takes into account the rail and tram 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. Public transport such as tram, train, and metro allows students to get on the bike on board and becomes 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. In this sense, the method considers, therefore, the possibility that cycling is used for last mile journeys, identifying roads that connect the metro/rail/tram stations to schools as priority roads where to place the new cycle facilities. The new cycle facilities should also be located near the trip attractors and generators, i.e. close to areas of historical and tourist interest, parks, public transport hubs and neighborhoods where residences (origins) are concentrated.

About the technical constraints, the location of the new cycle facilities depends primarily on the topography of the city. Interventions must also comply whit plans and regulations. All roads with a longitudinal slope greater than 5% have been rejected, as they are not suitable for the circulation of bicycles by law (Article 8 of Legislative Decree 557/1999). Another constraint is the type of road: it was discarded as a possible road on which to insert new bike facilities Viale Regione, which is a motorway, as the legislation does not allow it because the excessive difference between the speed of the cars and that of the bicycles increases the risk of accidents.

Through the application of the objective function it is possible to maximize the surplus of users: the public administration can invest where there is high cycling demand, realizing safe routes for students respecting technical constraints.

The process of optimization, applied to only four schools, resulted in the cycle paths in Fig. 5. They connect the schools to the places where the student residences are more concentrated, to the main train or tram stations, to the park and ride parking lots and to the existing bike-sharing docks, thus creating a continuous network.

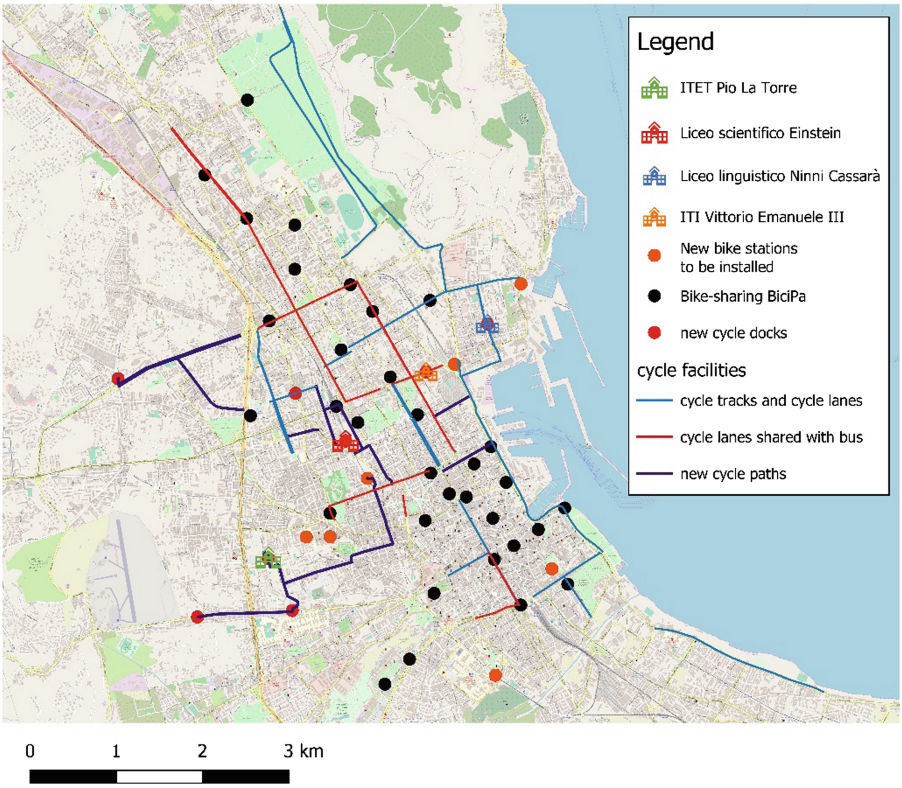


Fig. 5. New cycle paths resulting from the application of the optimization process.

7 Conclusion

One of the actions that policymakers can implement to encourage cycling, especially among young people, is the activation of special bike-sharing programs for schools.

The bike-sharing service succeeds in attracting demand from other modes of transport - first of all cars - not only with an appropriate distribution in the territory of bicycle docks but also with careful planning and placement of new cycling infrastructures. The location of the new cycle paths has to be decided on the basis of a methodology that maximizes the number of students can potentially take advantage of using the bike-sharing service, taking into account the addresses of their homes or the proximity to park and ride parking lots or stations railways for the identification of the streets in which to build new cycling infrastructure.

The methodology proposed here consists, therefore, in an optimization process that allows maximizing the users' "surplus", while taking into account in general investment costs and externalities. Investments, which are in any case limited, should be oriented where the presence of cycle paths can significantly increase the share of users using the bicycle. In terms of externalities, it is obvious that the more bikes there are, the more environmental benefits are obtained; however, externalities are very difficult to assess. In this paper, therefore, a compensatory process between investment costs and gain in terms of reduction of negative externalities has been considered. For the location of the new cycle paths and their design, technical constraints must also be taken into account: there must be a consistency of the interventions with the Sustainable Urban Mobility Plan and the existing regulations concerning the design of the cycle facilities.

The optimization process, which involves the development of an objective function, has been applied to the case study of Palermo, determining where new cycle infrastructure could be needed to ensure that students switch from private car use to cycling.

The method can be applied also to other cities and other contexts if the cycling demand and the constraints are well known. The methodology is, therefore, a valid decision support system for the public administration, as the optimization process indicates where the investments will give the best results.

Further studies, which take investments costs and externalities into account, will need to be performed. Calibrating the modal choice model considering other types of users, such as teachers and school staff, and extending the analysis to other schools will therefore necessary.

References

1. Amoroso, S., Migliore, M., Catalano, M., Galatioto, F.: A demand-based methodology for planning the bus network of a small or medium town. Eur. Transp. - Trasporti Europei **44**, 41–56 (2010)
2. Caggiani, L., Camporeale, R., Binetti, M., Ottomanelli, M.: An urban bikeway network design model for inclusive and equitable transport policies. Transp. Res. Procedia **37**, 59–66 (2019). https://doi.org/10.1016/J.TRPRO.2018.12.166

3. Di Dio, S., La Gennusa, M., Peri, G., Rizzo, G., Vinci, I.: Involving people in the building up of smart and sustainable cities: how to influence commuters' behaviors through a mobile app game. Sustain. Cities Soc. **42**, 325–336 (2018). https://doi.org/10.1016/J.SCS.2018.07.021
4. Dondi, G., Simone, A., Lantieri, C., Vignali, V.: Bike lane design: the context sensitive approach. Procedia Eng. **21**, 897–906 (2011). https://doi.org/10.1016/j.proeng.2011.11.2092
5. D'Orso, G., et al.: School bike sharing program: will it succeed? (in press)
6. European Commission: Città in bicicletta, pedalando verso l'avvenire (1999)
7. Faghih-Imani, A., Eluru, N., El-Geneidy, A.M., Rabbat, M., Haq, U.: How land-use and urban form impact bicycle flows: evidence from the bicycle-sharing system (BIXI) in Montreal. J. Transp. Geogr. **41**, 306–314 (2014)
8. Forsyth, A., Krizek, K.: Urban design: is there a distinctive view from the bicycle? J. Urban Des. **16**(4), 531–549 (2011). https://doi.org/10.1080/13574809.2011.586239
9. Fulton, J.E., Shisler, J.L., Yore, M.M., Caspersen, C.J.: Active transportation to school: findings from a national survey. Res. Q. Exerc. Sport **76**(3), 352–357 (2005)
10. Gebhart, K., Noland, R.B.: The impact of weather conditions on bikeshare trips in Washington, DC. Transportation **41**(6), 1205 (2014)
11. ISFORT. 13° Rapporto sulla mobilità in Italia (2016)
12. Lin, J.-J., Yu, C.-J.: A bikeway network design model for urban areas. Transportation (Amst). **40**, 45–68 (2013). https://doi.org/10.1007/s11116-012-9409-6
13. Mattson, J., Godavarthy, R.: Bike share in Fargo, North Dakota: keys to success and factors affecting ridership. Sustain. Cities Soc. **34**(July), 174–182 (2017)
14. McDonald, N.C.: Household interactions and children's school travel: the effect of parental work patterns on walking and biking to school. J. Transp. Geogr. **16**(5), 324–331 (2008)
15. Migliore, M., Catalano, M.: Urban public transport optimization by bus ways: a neural network-based methodology. WIT Trans. Built Environ. **96**, 347–356 (2007)
16. Migliore, M., Lo Burgio, A., Di Giovanna, M.: Parking pricing for a sustainable transport system. Transp. Res. Procedia **3**, 403–412 (2014)
17. Moro, S.R., Imhof, A.C., Fettermann, D.C., Cauchick-Miguel, P.A.: Barriers to bicycle sharing systems implementation: analysis of two unsuccessful PSS. Procedia CIRP **73**, 191–196 (2018). https://doi.org/10.1016/J.PROCIR.2018.03.312
18. Muhs, C.D., Clifton, K.J.: Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development. J. Transp. Land Use **2**, 147–188 (2015)
19. Schofield, G., Schofield, L., Mummery, K.: Active transportation: an important part of adolescent physical activity. Youth Stud. Aust. **24**(1), 43–47 (2005)
20. Statistics Netherlands (CBS). Netherlands Travel Survey (OViN) (2016)
21. Stewart, O., Vernez Moudon, A., Claybrooke, C.: Common ground: eight factors that influence walking and biking to school. Transp. Policy **24**, 240–248 (2012)
22. Wang, J., Lindsey, G.: Do new bike share stations increase member use: a quasi-experimental study. Transp. Res. Part A Policy Pract. **121**, 1–11 (2019). https://doi.org/10.1016/J.TRA.2019.01.004
23. Zhang, Y., Mi, Z.: Environmental benefits of bike sharing: a big data-based analysis. Appl. Energy **220**, 296–301 (2018)