Understanding the key factors of shared mobility services: Palermo as a case study

Alessandro Emilio Capodici[1], Gabriele D'Orso[1], Marco Migliore[1]

[1]Dept. of Engineering, University of Palermo
Viale delle Scienze Building 8, 90128 Palermo, Italy
alessandro.capodici@unipa.it
marco.migliore@unipa.it
gabriele.dorso@unipa.it

Abstract. The potential success of shared mobility services in the urban area strongly depends on careful tariff planning, adequate sizing of the fleet and efficient integrated public transport system, as well as on the application of policies in favor of sustainable modes of transport. The balance between earnings and expenses is not always an easy target for the companies in those cities where these services are not well-rooted in the citizens' mobility habits. Often only large operators in the sector can continue to offer a service generating profit. However, several factors can determine the success or the failure of shared mobility services. The objective of this study is to identify, thanks to the help of a case study, success and failure factors, developing an approach that is supportive for companies in managing the services and optimizing fares and fleet to increase the number of members and maximize profits. The city of Palermo has been chosen as a case study: the “Amigo” carsharing service - partly station-based, partly free-floating - is a service managed by the municipal company AMAT S.p.A., which operates also the public transport service.

Keywords: Shared Mobility · Fleet-size optimization · GIS · Bike sharing · Carsharing

1 Introduction

Shared mobility services have become in recent years increasingly present and used modes of transport in urban areas. In the past years, only a few carsharing companies competed for the slices of a rapidly growing market; now, many private and publicly-owned companies have entered in the shared mobility market and succeeded, creating a wide variety of shared mobility services. The success of these services can be found in its flexibility: members can use the car or the bike when they need it, booking the closest of those of the large fleet offered by the companies. Flexibility also means to be able to use different categories of vehicles according to own needs, such as city-cars, vans, or low-emission vehicles that often allow the user to move more freely, freeing himself from the restrictions on vehicular traffic adopted by municipal administrations. In this perspective, carsharing is an effective mode of transport especially for non-commuting trips and for those citizens who use both public transport and carsharing to satisfy their mobility needs in urban areas, not having a car always available.

Bikesharing, on the other hand, is suitable for those who have to make trips - even commuting trips - characterized by an intermediate distance between acceptable walking distances and distances that must be traveled by public transport, or for those who use this service as a feeder system to reach the main public transport hubs.

These mobility services are now incentivized not only to counteract the excessive use of the private car and what it entails, i.e. air and noise pollution, and soil consumption, alongside restrictive policies (road pricing, the introduction of restricted traffic areas and parking pricing) but also to give concrete form to the concept of Mobility as a Service, i.e. the offer of a transport system that includes various mobility services, integrating them physically and in fares.

However, some factors largely affect the efficiency of these services, the level of service, and, consequently, demand satisfaction.

For this reason, the success of such services is built only with careful planning. This planning consists in finding the optimal location of the stations (in station-based services) or the width of the rental area (in free-floating services), in the optimization of the number of stations and the number of stalls, in the optimization of the vehicle relocation operations, and finally in the fares and fleet-size optimization. It may happen that citizens don't use carsharing because the companies adopt fares perceived as too high or operate the service with such a small fleet that does not guarantee users the availability of a car nearby at the time of booking. The same thing happens for bikesharing services that don’t have an adequate number of bicycles. The attractiveness of the shared mobility services is determined by the level of service offered and by the costs. The level of service mainly depends on accessibility, i.e. the distance of the user's origin and destination from the pick-up and drop-off locations. However, accessibility depends also on the availability of vehicles at the stations, which is influenced by the fleet size and affects the operating and management costs of the system.

The paper aims to investigate the possible criticalities of shared mobility services, such as the size of the fleet and the lack of optimization of the fares to be adopted. The aim is also to propose an approach that allows solving the problems that the companies operating in the shared mobility sector must face, in order to increase the number of citizens who use these modes of transport as alternatives to private cars. The "Amigo" car-sharing service was chosen as a case study, active in the city of Palermo and managed by Amat S.p.A, a publicly-owned company that deals with city public transport. Section 2 will illustrate the existing literature on the sizing of shared mobility services’ fleets and the design of fares. Section 3 will describe the methodology implemented and the factors assessed. Section 4 will introduce the case study; in particular, the shared mobility services in Palermo will be described; an analysis of the pedestrian access to the stations and the relationship between shared services and public transport will be carried out. In Section 5 other potential critical issues of the services will be analyzed, through the comparison with other Italian cases. Conclusions and suggestions for future research are given in Section 6.

2 Background

Many researchers have investigated the factors influencing the success of shared mobility services [17] [2] [5] [12]. Much of the scientific literature is aimed at methodologies for determining the optimal number, size, and position of bikesharing and carsharing stations or for optimizing fleet rebalancing operations to increase efficiency, members and, hence, the profit for companies. On the other hand, few researchers have been interested in adapting fares and sizing the fleet to achieve an adequate balance between profits and customer needs; research in this field has mainly concerned the case of carsharing systems with electric vehicles.

Boyaci et al. [4] developed, for example, a multi-objective model for the planning of one-way carsharing systems with electric vehicles and the determination of the optimal fleet size, taking into account the dynamic processes of relocation and rebalancing, as well as the costs and the benefits for users and the company.

Li et al. [10] proposed a Continuum Approximation model to determine the optimal location of the stations of an electric one-way car-sharing and the size of the fleet; this model is based on the criterion of minimizing the operating costs of the system (investments for the construction of the stations, vehicle charging, fleet rebalancing): in particular, the authors considered how the charging times between one rental and the next affect the actual availability of cars at the stations.

The adequate size of the fleet of electric car-sharing service in Beijing [17] was estimated with a Monte Carlo simulation, considering the potential demand, arrival times, distance and travel time, as well as the charging times. Another proposed methodology for sizing the fleet of electric carsharing systems is the branch-and-price approach, which has the aim of minimizing the costs of the EV trip chain [15].

The rebalancing of the fleet and the assignment of personnel assigned to this operation were among the main factors considered by Xu et al. [16] in solving the problem of fleet sizing and trip pricing. The determination of the fares to be adopted to maximize profits in one-way car-sharing was also studied for Jorge et al. [9]: the researchers proposed an iterated local search (ILS) metaheuristic, taking into account how the possible variations to the travel rates by zone and by time slot can ensure that the rebalancing of the fleet can be done unknowingly by users, reducing company staff responsible for relocating shared cars. Perboli et al. [14] instead, simulated the introduction of new tariffs taking into account the different user-profiles and their needs.

The optimization of the location and size of the fleet can be the result of multi-agent simulations, in which supply and demand are modeled and the effects of the strategies proposed to increase the use of the available fleet are observed [1]. Barrios and Doig Godier [3] also used an agent-based model to optimize the fleet to maximize the number of trips for each vehicle.

Queue theory has also been used for station-based systems to optimize the fleet and optimally design the capacity of the stations [7] [8].

Finally, Nourinejad and Roorda [13] used an integrated dynamic simulation-optimization model to evaluate the performance of one-way systems, finding that increasing the booking time from 0 to 30 min can reduce the size of the fleet by 86 % and that the latter is linked to the times of relocation of the vehicles and the dispersion of requests over time.

3 Methodology

The factors that lead to success or failure by operators can be manifold. These factors are reported in Tab. 1, making the appropriate distinction between those related to bikesharing (dockless D and dock-based DB) and those related to carsharing (free-floating FF and station-based SB).

Table 1. Key success and failure factors of shared mobility services.

		Carsharing		Bike-sharing	
		FF	SB	D	DB
Key success factors	Fare integration	X	X	X	X
	Modal integration with public transport	X	X	X	X
	Fares that facilitate the rebalancing of the fleet	X	X	X	X
	Fleet optimization	X	X	X	X
	Optimization of the location of the stations in relation to the main attractor poles	-	X	-	X
	Traffic restrictions and pricing policies applied	X	X	X	X
	Presence of different types of vehicles in the fleet	X	X	-	-
	Presence of changing rooms and showers in the workplace	-	-	X	X
Failure factors	Fleet undersizing	X	X	X	X
	Fleet oversizing	X	X	X	X
	Absence of cycle paths	-	-	X	X
	Absence of charging stations for electric vehicles	X	X	-	-
	Absence of bicycle racks	-	-	X	-
	Lack of integration with public transport	X	X	X	X
	Poor pedestrian accessibility of the stations	-	X	-	X
	Bad fares	X	X	X	X
	Inefficient public transport system	X	X	X	X
	Adverse weather conditions, air pollution or adverse topography	-	-	X	X
	Occupation of stalls by unauthorized vehicles	-	X	-	-
	Long on-street parking search time	X	-	-	-
	Non-user-friendly booking systems	X	X	X	X

Many of the factors are, as already stated, related to the level of service offered by shared mobility systems: a number of vehicles in the fleet that does not guarantee the availability of the car to users at the time of booking strongly affects the success of these services in the urban area, as well as an inaccurate location of parking stalls in relation to the distance from the main attractor poles and their pedestrian accessibility [6]. Even fares perceived as too high by users or designed without an appropriate graduality, as well as complex booking systems, which require time and numerous steps, can influence the choice to make use of these services. Even too low tariffs and a high number of vehicles available to users are the cause of failure of these services: in these cases, the revenues would not cover the expenses made by the company for system management, even if the number of users attracted by the system could be higher. On the other hand, fares that are modulated based on requests and that facilitate the spontaneous rebalancing of the fleet, and a varied offer regarding the type of vehicles are strengths for companies. Integration with public transport - including fare integration - is also a strong incentive for the use of shared mobility services, as the two systems are complementary: it is possible to implement an integration between shared mobility services and public transport through mobility packages. Modal integration with public transport and the efficiency of the latter play an important role in the choice of shared mobility services since the users to whom these services are addressed are generally those who renounce the purchase of a car in favor of public transport for commuting trips and in favor of carpooling and bikesharing for non-commuting trips.

Other factors are, however, external to shared mobility companies. The weather (e.g., sunny, rain or snow), temperature, and air-pollution are factors that strongly affects the success of a bikesharing system. Usually, adverse weather conditions and colder temperature would significantly discourage travelers from cycling. The topography also affects the choice of bikesharing. Steeper roads, in particular, would significantly discourage the use of a bicycle. Air pollution can also decrease the number of cycling commuters on the road.

With regards to environmental and land use impacts, cycling-related infrastructure is an important factor that can impact bikesharing systems. An increase in the number of cycle lanes and bikesharing docks can promote the use of this non-motorized mode of transportation, reducing travel time and increasing safety and convenience.

Companies operating in the shared mobility sector should take these factors into consideration, evaluating them in advance.

Having identified the key success and failure factors for shared mobility services, this paper, therefore, aims to illustrate how these factors actually influence the success of shared mobility services in relation to a case study. The city of Palermo was chosen as a case study, in which both bikesharing and carsharing services are active. In particular, pedestrian access to the stations of both services and modal integration with public transport were assessed; the fare integration, the booking systems, and the city public transport system were subsequently discussed. Finally, the fairness of fleet size and fares was assessed, making a comparison with successful existing systems in other Italian cities.

4 The case study

The bikesharing and carsharing services in the city of Palermo are managed by the municipal company AMAT S.p.A, which also manages urban public transport. The “Car Sharing Palermo” service was developed in 2009, while the implementation of the bike-sharing system, called “BiciPA”, took place in 2016: both services were cofinanced by the Italian Ministry of the Environment. The bikesharing service has a fleet of 400 bicycles and 39 cycle docks (Fig. 1).

AMAT offers a station-based carsharing service (one-way and round trip) with 82 parking spaces located throughout the city and a fleet of 126 cars of various types (city cars, station wagons, vans). Moreover, AMAT has introduced in 2018 24 electric cars in the central area of Palermo for the free-floating service, identifying a rental area of 4.88 square kilometers (Fig. 2).

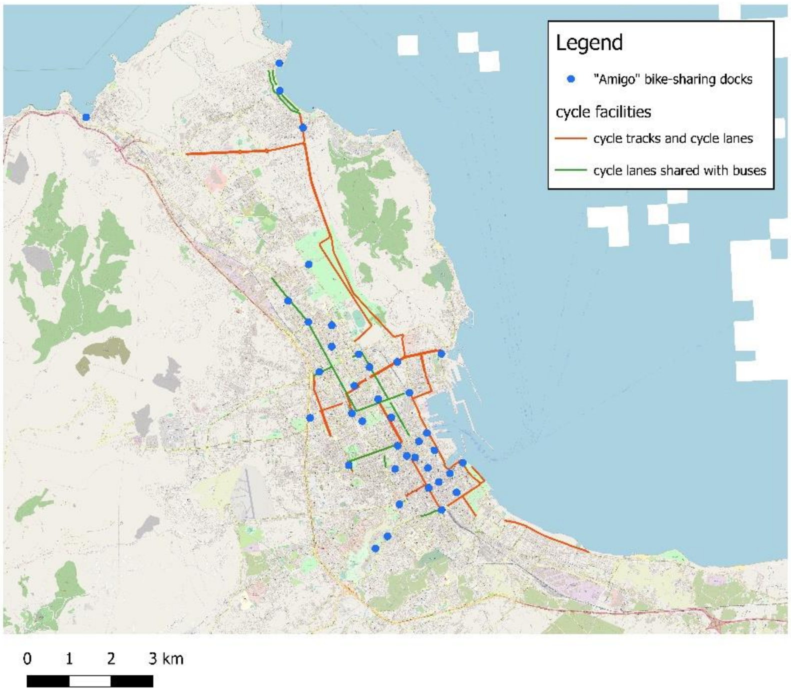

Fig. 1. Bikesharing docks in Palermo.

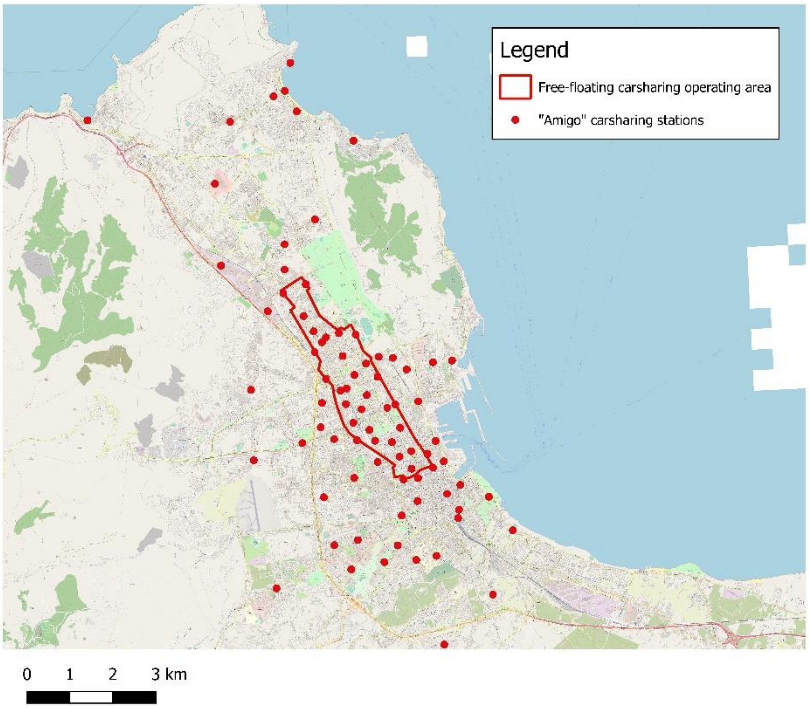

Fig. 2. Carsharing stations and free-floating operating area in Palermo.

The company has recently created a single platform, called "Amigo", which gives the possibility to use both shared mobility services. Booking is via app or web. The registration for the two services is unique and costs € 25.

The analysis of the financial statements of the AMAT S.p.A. company highlights an alarming fact: the sector is largely at a loss and the usage by the customers does not balance the costs that the company has to face. It is, therefore, necessary to analyze which reasons these losses have. First of all, the potential demand of the carsharing service that has been assessed as 10,000 daily users in Palermo in Migliore et al. [11] results in a lower number of members, equal to 4195 in 2020.

Pedestrian access to the bike-sharing and carsharing stations was first determined. This was done using the GIS software QGIS, carrying out buffering operations and processing the ISTAT data of the population census of 2011. The catchment areas and the number of citizens who reside or work at a walkable distance from the stations was assessed. The maximum distance considered walkable has been set at 500 m. For bikesharing, the autonomous and active population was considered, i.e. those aged between 14 and 70 years. For the calculation of potential users for carsharing, reference was made to citizens over the age of 18.

The results of the accessibility analysis in cartographic terms, i.e. the catchment areas considering the maximum walking distance along the road network, are shown in Figs. 3 and 4.

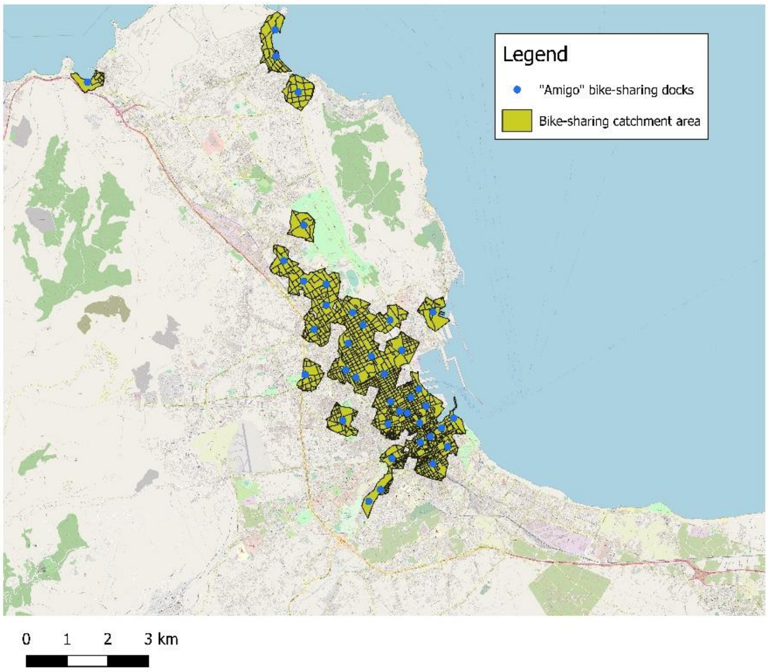

Fig. 3. Bikesharing catchment area (500 m).

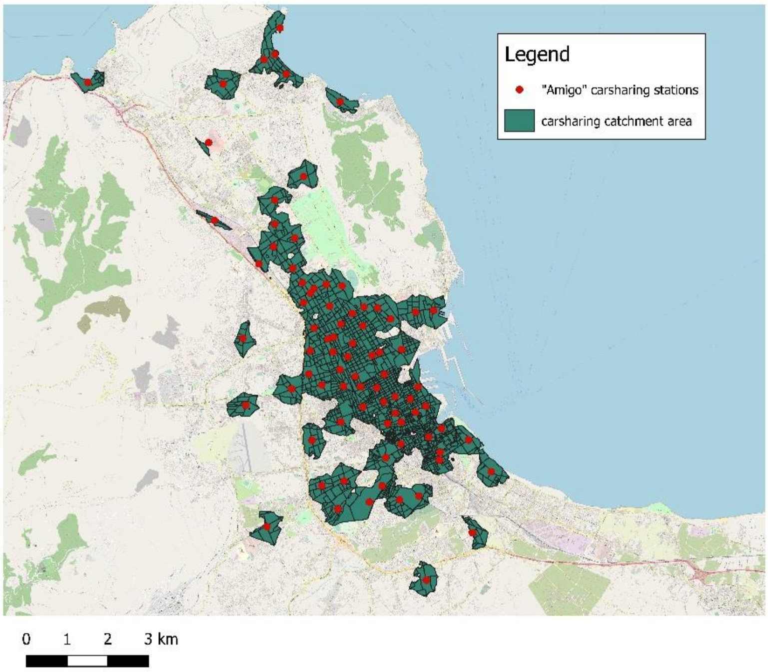

Fig. 4. Carsharing catchment area (500 m).

The number of residents and employees who live or work at a distance of 500 m from the bikesharing and carsharing stations is shown in Tab. 2 for both systems. In addition, the total number of residents and employees potentially served by considering both services is also reported.

Table 2. Population and employees within the catchment areas of the shared mobility services.

	500 m	
	Population	Employees
Bikesharing	93,710 (20%)	78,783 (42%)
Carsharing	199,835 (38%)	118,498 (63%)
Bikesharing Or Carsharing	216,612 (39%)	120,918 (64%)

Considering the distribution of citizens' residences in the territory, it is noted that bikesharing covers only 20% of potential users, while the carsharing service has greater accessibility (38%). Considering the accessibility of both services overall, in any case, they remain inaccessible for most of the potential users (61%). The accessibility of shared mobility services is greater if we consider the workplaces present in the area: 64% of the workplaces are located less than 500 m from a carsharing station or a bikesharing dock.

Subsequently, physical integration with public transport was assessed. Fig. 5 shows the catchment areas of the high-frequency or regular public transport lines (tram, train, and bus line 101). The number of citizens who live or work at a walkable distance both from regular or high-frequency public transport and from shared mobility services has been determined (Tab. 3). It was assessed using the GIS software (Fig. 6).

Table 3. Population and employees within the high-frequency or high-regularity public transport catchement area and within the areas with public transport and shared mobility services within a walkable distance.

	500 m	
	Population	Employees
Public Transport	176,274 (32%)	86,929 (46%)
Public Transport & Shared Mobility Services	97,452 (17%)	70,254 (37%)

Only 17% of citizens reside less than 500 m from both public transport and a carsharing or bikesharing station. This fact indicates poor physical integration between shared mobility services and public transport. In fact, only 39 of the 82 carsharing stations and 22 of the 43 bikesharing stations fall within a walkable distance from the stops of high-frequency or high-regularity public transport line.

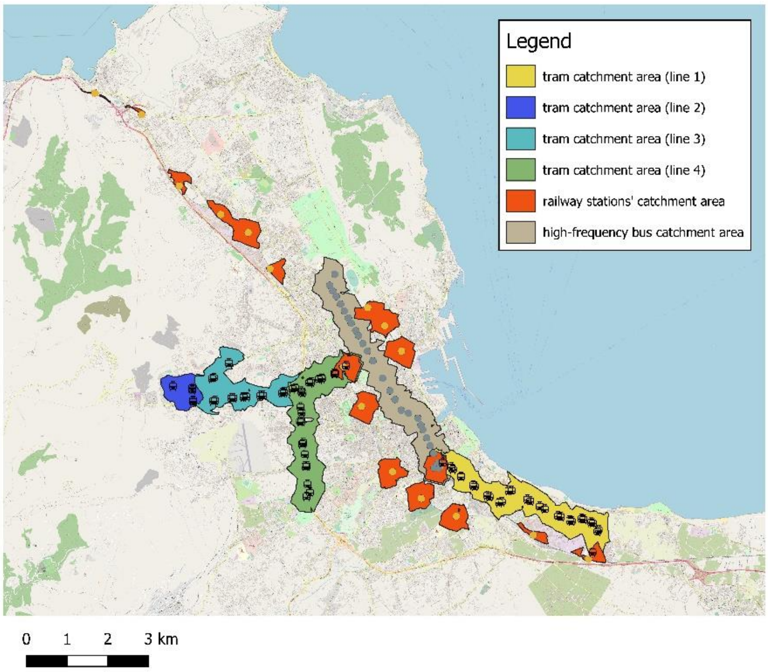

Fig. 5. High-frequency or high-regularity public transport catchment area (500 m).

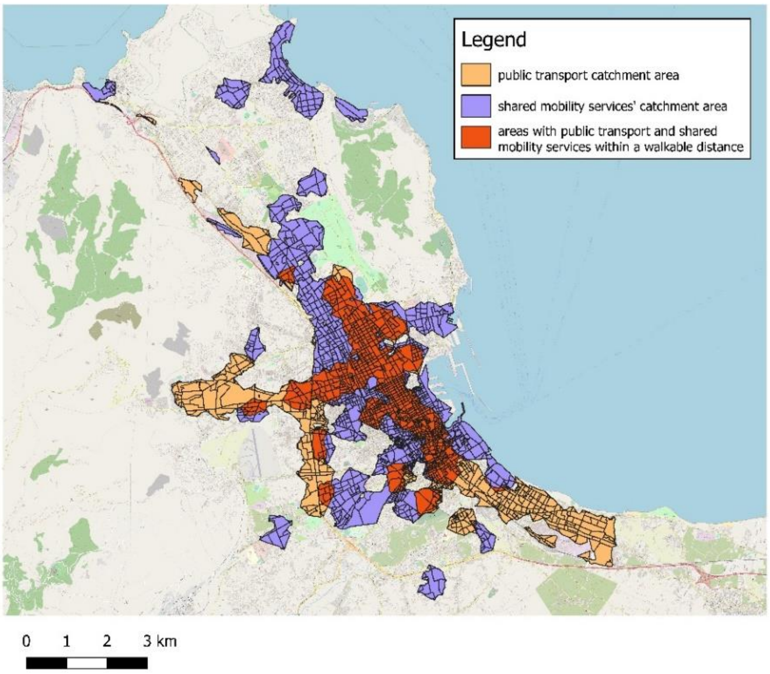

Fig. 6. Areas with public transport and shared mobility services within a walkable distance.

Therefore, the presence of fare integration was assessed: there is currently a fare integration between the two shared mobility systems. This integration consists of the common registration for the two services. There is no fare integration with public transport, although it would be easy to implement since the company that manages public transport operates also shared mobility services. The company could, therefore, create several mobility packages for different types of users.

Not advantageous fares and a complex booking system are some of the most critical issues of the services. This fact was highlighted by a customer satisfaction survey carried out in 2017 [11]. The users indicate an easier booking system (22.7%) and more promotions and offers (14.3%) as possible areas for improvement of the carsharing service. Another critical issue reported by users is the occupation of stalls reserved for carsharing by unauthorized vehicles, which prevents the drop-off of the vehicle, causing significant inconvenience in terms of a waste of time to search for a parking space.

Factors in favor of the use of the two shared mobility services in the city are the convenient fares of the bike sharing service (the free use of bicycles for the first 30 minutes) as well as the possibility to enter the restricted traffic area for carsharing vehicles, the possibility to drive in the bus lanes and to park for free in the on-street parking spaces.

5 Comparison with other Italian cities

Furthermore, it was investigated whether there were an undersized fleet or tariffs not in line with the main operators of Italian carsharing services at the basis of the gap between revenues and expenses.

In this sense, a comparison was made between the Amigo service and the carsharing services offered in the main Italian cities where these services are established and used: Milan, Rome, Turin, Florence, and Bologna. In the comparison, taking into account the specificities of the different cities, some factors that may influence the success of the service were discussed: population density, motorization rates and age of the vehicles in circulation, the efficiency of public transport (Tab. 4). Table 5 shows the results of the comparison in terms of fleet and number of members.

Despite having a greater number of inhabitants than Bologna and Florence, Palermo has a smaller fleet of carsharing vehicles. It is possible to note that in these two cities, as well as in Turin, Milan, and Rome, there are several operators, which increase the supply. Furthermore, if you compare the number of free-floating vehicles available, the Amat service has only 24 electric vehicles available: a much lower number than the services of the other cities.

The fleet under-sizing inevitably leads to a lower number of members, due to the unavailability of close shared cars at the time of booking, and therefore to an unsatisfactory level of service. The unavailability of shared vehicles was indicated as the most urgent area for improvement by users of the service during the customer satisfaction survey (28.4% of the interviewees indicated it).

The citizens of Palermo also show a deep-rooted use of the private car: after Turin and Rome, Palermo is the city with the highest motorization rate and the circulating vehicles are older than in the other cities: about 43% of circulating vehicles have emission standards equal to or lower than the Euro 3. This is the sign that the inhabitants do not give up private cars in favor of the more recent carsharing vehicles. The affection for private cars also derives from a public transport supply that is significantly reduced compared to the other cities. Furthermore, the efficiency of public transport is much less than in the other cities: from the data of the Moovit Report, it is evident that the waiting time at the public transport stop in Palermo is about 25 minutes, more than double than in the cities of Milan, Bologna, and Florence, and greater than in the cities of Turin and Rome. Besides, the public transport user is forced to walk long distances to reach his destination, an irrefutable sign of reduced public transport accessibility in Palermo compared to other cities.

This means that the typical carsharing user - the one who uses public transport for commuting trips and the shared mobility service for non-commuting trips - does not manifest itself, mainly due to the lack of reliability that is attributed to public transport.

From the comparison of the number of carsharing members in Tab. 5, it can be seen that the number of members in Palermo is very low than in the other cities, although in these cities there are different operators. The station-based service fares are lower than those on the market (except for the Ubeeqo service in Milan), while the free-floating service fares are in line with the other Italian carsharing services.

Table 4. Specificities of the analysed cities.

	Population [inhabitants]	Population density [people per km^2]	Motorization rate [cars per 1000 people][1]	Percentage of cars with Euro 3 standard or lower[1] [%]	Public transport[2]: available seat-kilometres [km]	Public transport[3]: average waiting time [min]	Public transport[3]: average walking distance during a single commute by transit [m]
Torino	874,935	6,729.75	666	27.4	6016	13.17	726.25
Milano	1,387,171	7,635.66	512	29.2	16218	9.1	715
Bologna	392,027	2,783.1	540	23.1	3742	10.04	762.5
Firenze	379,563	3,709.57	530	24.3	5541	10.51	753.75
Roma	2,879,728	2,236.93	623	30.9	6823	16	663.75
Palermo	659,894	4,109.18	596	42.5	2034	24.19	811.25

[1] ACI, 2018

[2] ISTAT, 2015

[3] Moovit Global Public Transport Report, 2019

Table 4. Comparison between the carsharing operators in the Italian cities.

	Operators		Fares	Fares (1 hour and 10 km)	Vehicles per city	Vehicles	Subscribers
Torino	SB	Bluetorino	0.195 €/min	11.7 €	908	187	-
	FF	car2go	0.19-0.29 €/min	11.4-17.4 €		721	181,215
		Enjoy	0.25 €/min	15 €			
Milano	SB	Ubeeqo	5 €/h	5 €	3201	150	-
	FF	car2go	0.19-0.29 €/min	11.4-17.4 €		3051	815,868
		Drivenow	0.31 €/min	18.6 €			
		Enjoy	0.25 €/min	15 €			
		Share'ngo	0.28 €/min	16.8 €			
Bologna	FF	Corrente	0.25 €/min	12€ (sale)	220	120	13,976
		Enjoy	0.25 €/min	15 €		100	
Firenze	FF	Adduma car	0.18 €/min	10.8 €	522	100	125,493
		car2go	0.19-0.29 €/min	11.4-17.4 €		422	
		Enjoy	0.25 €/min	15 €			
		Share'ngo	0.28 €/min	16.8 €			
Roma	SB	Carsharing Roma	3 €/h + 0.59 €/km	8.9 €	2303	192	-
	FF	car2go	0.19-0.29 €/min	11.4-17.4 €		2111	584,966
		Enjoy	0.25 €/min	15 €			
		Share'ngo	0.28 €/min	16.8 €			
Palermo	SB/FF	amigo	SB: 2.40 €/h + 0.54 €/km FF: 0.24 €/min	SB: 7.8 € FF: 14.4 €	150	150	4,195

6 Discussion and Conclusion

The paper highlighted how to evaluate certain factors such as the number of vehicles in the fleet, pedestrian accessibility, fare designing and integration with local public transport before the launch of the service is fundamental for a company that operates shared mobility services, such as carsharing and bikesharing. These factors affect the success of the shared mobility service in the urban area, in terms of citizens who will be members of the service. The unavailability of vehicles, the distance of the stations from the attractor poles, too expensive or too low fares, and the inefficiency of local public transport lead to a service not rooted in the citizens' mobility habits.

To highlight how these factors affect the success of the services and propose an approach to their evaluation, the “Amigo” shared mobility services platform of the city of Palermo was chosen as a case study. In particular, through GIS processing, data analysis and comparison with the services present in other Italian cities, it has been shown that there is a very small fleet compared to that of other cities and public transport is less efficient in Palermo. The location of bikesharing docks and carsharing stations means that the access to shared mobility services is limited: 61% of potential users live more than 500 m from a carsharing station or a bikesharing dock. It has also been found that physical integration with high-frequency or regular public transport lines is also poor: only 17% of potential users reside at a distance less than 500 m from a carsharing station or a bikesharing dock and from a public transport stop to take a regular, high-frequency public transport line. Other failure factors are the lack of fare integration with public transport, a complex booking system and the propensity for the use of the private car by the inhabitants of Palermo. The costs of using the services and the advantages offered by the operator (entry into the restricted traffic area, the possibility of free parking, use of bicycles for free for the first 30 minutes) were found in line with the services offered in other Italian cities.

The approach used is generalizable and applicable to identify critical issues and potentialities of shared mobility services in other cities and other contexts.

References

1. Balac, M., Ciari, F., 2015. Enhancement of the carsharing fleet utilization. 15th Swiss Transp. Res. Conf.
2. Balac, M., Ciari, F., Axhausen, K.W., 2017. Modeling the impact of parking price policy on free-floating carsharing: Case study for Zurich, Switzerland. Transp. Res. Part C Emerg. Technol. 77, 207–225. https://doi.org/10.1016/J.TRC.2017.01.022
3. Barrios, J. A., Godier, J. D., 2014. Fleet Sizing for Flexible Carsharing Systems: Simulation-Based Approach. Transportation Research Record, 2416(1), 1–9. https://doi.org/10.3141/2416-01
4. Boyacı, B., Zografos, K.G., Geroliminis, N., 2015. An optimization framework for the development of efficient one-way car-sharing systems. Eur. J. Oper. Res. 240, 718–733. https://doi.org/10.1016/J.EJOR.2014.07.020
5. Celsor, C., Millard-Ball, A., 2007. Where does carsharing work? Using geographic information systems to assess market potential. Transportation Research Record. https://doi.org/10.3141/1992-08
6. D’Orso, G., Migliore, M., 2020. A GIS-based method for evaluating the walkability of a pedestrian environment and prioritized investments. J. Transp. Geogr., 82, 102555. https://doi.org/10.1016/j.jtrangeo.2019.102555.
7. George, D.K., Xia, C.H., 2011. Fleet-sizing and service availability for a vehicle rental system via closed queueing networks. Eur. J. Oper. Res. 211, 198–207. https://doi.org/10.1016/J.EJOR.2010.12.015

8. Hu, L., Liu, Y., 2016. Joint design of parking capacities and fleet size for one-way station-based carsharing systems with road congestion constraints. Transp. Res. Part B Methodol. 93, 268–299. https://doi.org/10.1016/J.TRB.2016.07.021
9. Jorge, D., Molnar, G., de Almeida Correia, G.H., 2015. Trip pricing of one-way station-based carsharing networks with zone and time of day price variations. Transp. Res. Part B Methodol. 81, 461–482. https://doi.org/10.1016/J.TRB.2015.06.003
10. Li, X., Ma, J., Cui, J., Ghiasi, A., Zhou, F., 2016. Design framework of large-scale one-way electric vehicle sharing systems: A continuum approximation model. Transp. Res. Part B Methodol. 88, 21–45. https://doi.org/10.1016/J.TRB.2016.01.014
11. Migliore, M., D'Orso, G., Caminiti, D., 2018. The Current and Future Role of Carsharing in Palermo: Analysis of Collected Data and Results of a Customer Satisfaction Survey, 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), Palermo, pp. 1-6. doi: 10.1109/EEEIC.2018.8494010
12. Nobis, C.,2006. Carsharing as Key Contribution to Multimodal and Sustainable Mobility Behavior: Carsharing in Germany. Transportation Research Record, 1986(1), 89–97. https://doi.org/10.1177/0361198106198600112
13. Nourinejad, M., Roorda, M.J., 2014. A dynamic carsharing decision support system. Transp. Res. Part E Logist. Transp. Rev. 66, 36–50. https://doi.org/10.1016/j.tre.2014.03.003
14. Perboli, G., Ferrero, F., Musso, S., Vesco, A., 2018. Business models and tariff simulation in car-sharing services. Transp. Res. Part A Policy Pract. 115, 32–48. https://doi.org/10.1016/j.tra.2017.09.011
15. Xu, M., Meng, Q., 2019. Fleet sizing for one-way electric carsharing services considering dynamic vehicle relocation and nonlinear charging profile. Transp. Res. Part B Methodol. 128, 23–49. https://doi.org/10.1016/J.TRB.2019.07.016
16. Xu, M., Meng, Q., Liu, Z., 2018. Electric vehicle fleet size and trip pricing for one-way carsharing services considering vehicle relocation and personnel assignment. Transp. Res. Part B Methodol. 111, 60–82. https://doi.org/10.1016/J.TRB.2018.03.001
17. Yoon, T., Cherry, C.R., Jones, L.R., 2017. One-way and round-trip carsharing: A stated preference experiment in Beijing. Transp. Res. Part D Transp. Environ. 53, 102–114. https://doi.org/10.1016/J.TRD.2017.04.009
18. Yoon, T., Cherry, C.R., Ryerson, M.S., Bell, J.E., 2019. Carsharing demand estimation and fleet simulation with EV adoption. J. Clean. Prod. 206, 1051–1058. https://doi.org/10.1016/J.JCLEPRO.2018.09.124