Traditional and Innovative Vehicle-Sharing Models

Marika Arena, Giovanni Azzone and Irene Bengo

Abstract In recent years, car-sharing models have undergone relevant changes, leading to the emergence of different operational models, managerial and technological solutions, and more in general different vehicle-sharing configurations. These models are able to answer in different ways to potential mobility needs, put forth by both individual citizens and firms, leading to the idea that vehicle sharing should be not conceived as a standard service. In this context, this chapter outlines the evolution of different car-sharing models emerged from the literature review and discusses Green Move configurations with specific reference to the condominium car sharing, the network of services, and the new business fleet.

1 Introduction

Since its introduction in the late 1980s, the concept of car sharing has evolved in order to adapt its functioning to different changes that have been taking place in the social ecosystem. The core idea on which car sharing is based remained the same—i.e., replacing private ownership of cars with the access to a mobility service, coherently with the so-called access age (Rifkin 2000). However, the operational models whereby this idea can be enacted have changed significantly, leading to the rise of different service configurations.

This evolution has been determined by a mix of innovation impulses that can be related to both the development of the technology and the change in the market demand.

M. Arena (✉) · G. Azzone · I. Bengo
Department of Management, Economics and Industrial Engineering,
Politecnico di Milano, Via Lambruschini 4/B, 20156 Milan, Italy
e-mail: marika.arena@polimi.it

G. Azzone
e-mail: giovanni.azzone@polimi.it

I. Bengo
e-mail: irene.bengo@polimi.it

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The first relevant impulse to new car-sharing services was given by the diffusion of new technologies for the so-called smart mobility that according to Chun and Lee (2015) can be defined as "a concept of comprehensive and smarter future traffic service in combination with smart technology." In general terms, the concept of smart mobility is broad and refers to the idea of enhanced mobility, environmental sustainability, and inclusiveness. Hence, it depends on a plurality of factors ranging from an efficient means of public transport having a low environmental impact (reduced greenhouse gas emissions and energy consumption), a network of safe and continuous cycle lanes, interchange parking that avoids the city congestion, and also the availability of adequate car-sharing or more in general vehicle-sharing services (Garau et al. 2016).

In this context, two technological trajectories appear particularly relevant for explaining the evolution of car-sharing service configurations. First, several initiatives have highlighted how information and communication technologies (ICT) can be used to achieve smart mobility by modifying individual mobility behavior and lowering energy use and greenhouse gas emissions. In particular, the recent literature is converging on the idea that ICT is gradually enriching travelers' spatial and temporal practices (Aguiléra et al. 2012). From this perspective, ICT has opened up new opportunities in relationship to car-sharing configurations, facilitating a wide range of operations (such as reservation, vehicle localization, access) and enabling new services (Shaheen and Cohen 2007; May et al. 2008).

The second technological trajectory that is influencing the evolution of car-sharing configurations is represented by electric mobility. Indeed, there is a general expectation concerning a shift from internal combustion engine (ICE) to electric vehicles (EVs) in western countries' cities. This expectation is confirmed by the investments of the principal car producers, which are dedicating growing resources to develop hybrid and electric car models (e.g., Toyota, Peugeot, Nissan). In this context, several cities have introduced EV-sharing services as a means of dealing with the problem of congestion and urban pollution (e.g., Boyacy et al. 2015). The possibility of relying on a shared fleet of EVs has represented a means for dealing with some problems generally associated with e-mobility: higher costs compared to traditional ICE vehicles and the need of creating an adequate infrastructure for ensuring the possibility of recharging EVs.

In addition to the technological evolution, a further stimulus for the rise of new vehicle-sharing configurations came from the characteristics of the market demand —i.e., mobility demand of potential vehicle-sharing users. Roughly speaking, the attractiveness of car-sharing systems depends on two key factors (Boyaci et al. 2015):

- the level of service offered;
- the cost associated with the use of the system.

However, the level of service is a multidimensional construct that in turn depends on many different factors such as capillarity, flexibility, interoperability, multimodality, easiness of reservation, access and use, etc.. In recent years, mobility

behaviors of private citizens have evolved and the expectations of car-sharing (potential) users toward this service reflect this change. From this point of view, a key issue is that different vehicle-sharing configurations answer in a different way—i.e., leveraging on different performance—to passenger demand for mobility (e.g., Efthymiou et al. 2013).

Against this consideration, this chapter aims to outline the evolution of different car-sharing service configurations based on a literature review and introduce the innovative configurations developed with the Green Move project highlighting how these configurations respond to different mobility profiles.

Accordingly, the rest of this chapter is articulated as follows: Section 2 presents a literature review of different car-sharing models; Sect. 3 identifies the key performance dimensions against which a car-sharing configuration can be assessed; Sect. 4 introduces the Green Move car-sharing configurations; Sect. 5 concludes with possible paths for future research.

2 The Evolution of Car-Sharing Models

In the literature, car-sharing models have been traditionally classified along two main axes (e.g., Boyaci et al. 2015), distinguishing between:

- "Two-way" versus "one-way" car-sharing systems;
- "Non-floating" systems versus "free-floating" car-sharing systems.

Moving from the first axis, two-way car-sharing systems rely on the idea that the users have to return the rented vehicle at the same location where they picked it up. Instead, in one-way car-sharing systems, the users have the possibility of returning the rented vehicle at a different station compared to where they picked it up.

Concerning the second axis, in non-floating systems, users can pick up and have to drop off vehicles in specific locations—i.e., designated parking spots. Instead, in free-floating systems, the users do not have any restriction in connection with parking spots. They can pick up or drop off vehicles in any parking spot within a predefined area.

Analyzing the evolution of the car sharing, we can distinguish four main car-sharing models:

- Neighborhood car sharing (two-way, non-floating);
- Stations cars (one-way, non-floating);
- Multinodal shared-use vehicles (one-way, non-floating);
- Free-floating car sharing (one-way, floating).

The neighborhood car sharing is the original car-sharing model. It is based on the two-way system, and it is characterized by a network of shared-use vehicles that are settled in strategic locations (Shaheen and Cohen 2007). Car-sharing users in this

configuration typically reserve a vehicle in advance. At the time of the rental, the user gains access to the vehicle, carries out his trip, and returns the vehicle back to the same station he originally picked up it from (Shaheen and Cohen 2007, 2012).

Different car-sharing configurations were developed adapting this basic idea in order to answer to the mobility needs of a specific community—e.g., business car sharing, college/university car sharing, government and institutional car sharing, vacation/resort car sharing. In this way, some tailored car-sharing configurations started to emerge and were characterized by the either exclusive-use vehicles that are shared among clients belonging to a specific community—firms, students, public servants, tourist—or by shared-use vehicles where the clients access the vehicles as part of a larger car-sharing fleet.

The second basic model is represented by the station cars. In this configuration, parking stations are settled at public transport stations, and commuters can pick up vehicles for covering the trip between their home and the station or the station and their working place (Shaheen and Cohen 2007). This configuration was conceived in order to enhance transit connectivity and enable public transit to access to locations that are typically served by private vehicles. For this reason, it is often associated with providing "first and last mile connectivity" (Shaheen and Cohen 2007).

The third model is the multinodal shared-use vehicles. This is a one-way model with multiple stations that are placed at different points of interest (such as hotels, shopping malls, tourist attractions, firm, and university premises). Users are then free to pick up a vehicle from any point of interest and leave it at any station, without having to return it to the same location from which it was accessed (Shaheen and Cohen 2007). This model is clearly more complex than the previous one, because it entails a higher level of flexibility for the clients in terms of possible trips. It can also be integrated with some of the previous configurations; for instance, multinodal systems could also be directly linked to transit, when one station is placed in a relevant transit point. This possibility makes this configuration very interesting in terms of potential contribution to urban mobility, but also calls for advanced instruments for running the service (e.g., Boyaci et al. 2015).

Finally, the last model is the free-floating car sharing. In this configuration, traditionally fixed stations are substituted by extended areas where the car is allowed to be hired and left after the rental. The vehicles are distributed freely over that area and can be tracked by the customer via Internet or mobile phone applications together with information about their level of fuel as well as their inner and outer state of cleanliness (Firnkorn and Müller 2011). Obviously, this change has relevant implications on how free-floating car-sharing works and how users can access and use this service. This model aims to provide users more flexibility compared to other car-sharing models. Being a one-way system, one-way journeys are allowed. Booking a vehicle in advance is possible but not compulsory; thus, the cars may be taken spontaneously in the street (Firnkorn and Müller, 2011).

These conditions ensure the users much flexibility, but also lead to higher managerial complexity.

To conclude the analysis of the state-of-the-art literature concerning different car-sharing models, an emerging trend must be mentioned: the personal vehicle-sharing paradigm. This new paradigm cannot be brought back to the above taxonomy, because this practice is something quite different compared to car sharing itself, even if it is often cited as an emerging car-sharing operational model (e.g., Shaheen and Cohen 2012, 2013). Personal car sharing, also referred to as peer-to-peer car sharing, is a system in which car owners exploit their personal cars as shared vehicles and rent them to other drivers on a short-term basis (Hampshire and Gaites 2010, Shaheen et al. 2012; Shaheen and Cohen 2013). There are many different ways in which personal vehicle sharing can be deployed ; Shaheen and Cohen (2013) identify four sub-models of personal vehicle sharing: 1) fractional ownership, 2) hybrid peer-to-peer -traditional car sharing, 3) P2P car sharing, and 4) P2P marketplace (see Shaheen and Cohen 2013). P2P car-sharing sub-model is described in Chap. 5.

The review of the state-of-the-art literature has highlighted a wide variety of possible car-sharing configurations that can answer to user mobility needs in different ways. In the next paragraphs, the Green Move configurations will be discussed, pinpointing how they have been conceived, starting from the existing models, in order to answer to different mobility profile.

3 Mobility Profiles and Vehicle-Sharing Performance

The four service configurations have been analyzed taking care of:

- The potential mobility profiles to whom a vehicle-sharing service could answer and
- The mobility performance that is particularly relevant in connection with such profiles.

Since different performances often entail some trade-offs, a vehicle-sharing service should be configured focusing on those performances that are coherent with the mobility profiles it aims to privilege (see also Arena et al. 2015).

3.1 Mobility Profiles

Mobility profiles describe the basic characteristics of the trips performed by vehicle-sharing users. In other words, they represent the specific "need of mobility" to whom the vehicle-sharing service is aimed to answer (Millard-Ball 2005; EU Commission 2010; Sioui et al. 2013).

The literature review allowed to identify eight different mobility profiles:

1. Commuter: regular trips between the home and workplaces (or schools);
2. Shopping: recreational travel in the city center, generally characterized by multiple and unpredictable stops;
3. Neighborhood trip: travel focused in local areas for daily activities (e.g., shopping, driving children to school);
4. Tourist in the city: recreational travel aimed at visit different attractions;
5. Nightlife: recreational travel during evening and night;
6. Business trip: business travel between stations/airports and a meeting place;
7. Moving in the campus: travel limited in certain space (e.g., campus);
8. Business fleet: travel for business purposes performed by the employees using a vehicle-sharing fleet.

3.2 Vehicle-Sharing Performance

A vehicle-sharing performance represents the key characteristics that allow to answer to different mobility profiles. Based on the literature review, we identified ten performance dimensions (Barth and Shaheen 2002; Millard-Ball 2005; May et al. 2008; EU Commission 2010):

1. Capillarity: number and location of the stations. Higher capillarity reduces the access time to the system, making a vehicle-sharing service more similar to the car ownership and allows to capture a larger potential demand (Cohen et al. 2008);
2. Flexibility: lack of constraints in terms of choice of the release station and scheduling time. Flexibility can be related to two main dimensions:
   a) Space: the customer is allowed to release the vehicle in a station other than where the vehicle was picked up;
   b) Time: the customer is allowed to access the vehicle without reservation and/or to make an open-end reservation, without fixed time limits;
3. Intermodality: possibility to integrate the vehicle-sharing service with other public transport (underground, train, etc.). This concept can be declined into:
   a) Interoperability: the use of integrated access devices (e.g., a single smart card) valid for different types of transportation;
   b) Multimodality: location of parking stations near the public transport;
4. Rate: price charged to the customer for the vehicle's usage. It consists of different components, such as subscription costs, kilometer and hour rate, penalties, that can be totally waved or incremented;
5. Availability of incentives: forms of facilitation to encourage service use; they include, for instance, access to free parking areas and limited traffic areas;

6. Vehicles: number and types of vehicles available; the vehicles must be adaptable to different needs in terms of interior (seats and luggage) and range distances;
7. Easiness of access and use: simplicity of the procedures to access and use a vehicle, so that it does not differ significantly from privately owned vehicles. It can be related to:
   a) Access time: opening/closing hours that determine when the vehicle can be accessed by users (the optimal situation is 24 h) and
   b) Lock/unlock system and driving style;
8. Easiness of the payment system: simplicity of the payment process that allows the customer to quickly access the service without lengthening the total journey time or creating barriers to the service use (e.g., mandatory request of the credit card);
9. Easiness of the reservation system: simplicity of the process required to reserve a vehicle and book the arrival station (in the multinodal service);
10. Additional services: ancillary services that complement the basic performances.

The analysis of performance dimensions has been used as starting point for the design of the Green Move simulation model (Sect. 3).

4 Vehicle-Sharing Configurations

This paragraph introduces the three vehicle-sharing configurations developed within the Green Move project:

- The condominium car sharing;
- The network of services; and
- The new business fleet.

4.1 Condominium Car Sharing

The basic idea of condominium car sharing consists in an EV-sharing service deployed on a condominium basis. It brings to the extreme the neighborhood operational model narrowing the sharing base to the condominium. In this way, the users have the possibility of booking and picking up the vehicle inside their own condominium and use them for two-way trips. Referring to the mobility profiles previously defined, this configuration aims to serve the mobility profiles connected to “neighborhood trip” and “nightlife.”

In the condominium car sharing, the capillarity is the main strength of the service. It helps to overcome one of the principal barriers that obstacle car-sharing

Table 1 Condominium car-sharing performances

Capillarity	Inside the condominiums
Flexibility—space	Two-way service
Flexibility—time	No reservation
Multimodality	There are no stations near the local public transport
Interoperability	No. The service is operated by a mobile application
Rate	Preliminary hypothesis of 5 €/h (7 a.m.–7 p.m.) and 3 €/h (7 p.m.–7 a.m.)
Availability of incentives	Area C and blue parking stripes "Sosta Milano" are free, and it is also possible to park on yellow lines for residents
Vehicles	2 different car models
Easiness of access and use	Cars are available 24 h on 24, every day of the year. Using a mobile application, it is possible to open the doors
Easiness of the payment system	Automatically by smartphone
Easiness of the reservation system	It is possible to book the car from the Web site or with the mobile application
Additional services	No additional services

use, i.e., the distance from the station of collecting/delivery of the vehicle. Other positive aspects concern the safety for both vehicles and users, as cars are kept within a protected area and the possibility to integrate peer-to-peer approaches due to the immediate community. On the other hand, the main weaknesses of this configuration consist in the rigidity of the system due to the possibility to perform two-way trips only and the difficulties to provide common areas for the vehicles parking, in existing condominium. Table 1 synthesizes the main performances of the service.

The condominium car-sharing configuration has been tested within Green Move activities, as depicted in Chap. 6.

4.2 Network of Services

The second configuration focuses on shopping and recreation profiles ("shopping," "tourist in the city," and "nightlife"). Based on the competitive analysis, a widespread mobility profile resulted to be linked to free time and shopping-related occasions. However, the existing services do not favor this travel pattern as they are not directly connected with recreational areas.

Hence, the second configuration bases on the multinodal operational model in which cars are driven among multiple stations or nodes to travel from one activity center to another and integrate the electric mobility service with other services offered in key areas of the city (e.g., shopping centers, cultural centers, health structures, city center, public transport stations, relaxation/fun centers, night

Table 2 Network of services performances

Capillarity	Stations located near the main city nodes
Flexibility—space	One-way service
Flexibility—time	No reservation
Multimodality	Stations located also near the local public transport
Interoperability	No. The service is operated by a mobile application
Rate	Preliminary hypothesis of 7 €/h
Availability of incentives	Area C and blue parking stripes "Sosta Milano" are free, and it is also possible to park on yellow lines for residents
Vehicles	Four different car models
Easiness of access and use	Cars are available 24 h on 24, every day of the year. Using a mobile application, it is possible to open the doors
Easiness of the payment system	Automatically by smartphone
Easiness of the reservation system	It is possible to book the car from the Web site or with the mobile application
Additional services	Service integration with main point of interest of the city

amusement sites). In this way, it is possible to improve the accessibility of vehicle-sharing users to key nodes, relying on the possibility of integrating vehicle sharing with the services offered by the nodes themselves. The basic idea of network of services is to involve other service providers in the vehicle-sharing initiative by:

- positioning the stations, the sites of these nodes to satisfy the needs of mobility of their users/visitors and
- integrating other mobility systems and services delivered by the node in a proper manner.

Key feature of this configuration is the possibility of performing one-way trips between nodes, i.e., releasing the vehicle in a parking station other than the departure one. To the users will be given the possibility to release the vehicle in the node more convenient to them and to interact with the service provider (for instance, by purchasing the museum access from the vehicle). In addition, including the main public transport stations among the key nodes, the "network of services" configuration could also support intermodal travels. Table 2 summarizes the main performances of the service.

4.3 The New Business Fleet

The business segment is an emerging market for vehicle-sharing initiatives; hence, the third configuration consists in an electric vehicle-sharing initiative targeting firms and public institutions. In this case, the main idea of the service is to both

Table 3 New business fleet performances

Capillarity	Inside the firms
Flexibility–space	One- and two-way services
Flexibility–time	Reservation is mandatory
Multimodality	There are no stations near the local public transport
Interoperability	No. The service is operated by a mobile application
Rate	Four different rate plans differentiated on the firm specificity
Availability of incentives	Area C and blue parking stripes "Sosta Milano" are free, and it is also possible to park on yellow lines for residents
Vehicles	Four different car models
Easiness of access and use	Cars are available 24 h on 24, every day of the year. Using a mobile application, it is possible to open the doors
Easiness of the payment system	Automatically by smartphone
Easiness of the reservation system	It is possible to book the car from the Web site or with the mobile application
Additional services	No additional services

substitute business fleets owned by local companies with a shared one (i.e., each firm can purchase a mobility package) and provide an alternative mobility service to the employees. Accordingly, this configuration aims to serve the "business fleet" and "commuter" profiles. The main characteristics of this configuration are:

- use of the vehicles from the companies on working time and from their employees for private use on spare time (evening and weekend);
- availability of parking lots for the vehicles inside company premises.

This configuration has several positive aspects such as the possibility to integrate peer-to-peer approaches. In fact, confidence in colleagues and the much time spent at the workplace help a possible sharing of the private car. Moreover, the service improves the transparency and traceability of employee travels. A weakness concerns the last mile problem, not solved by this configuration. In Table 3, the main performances of the service are summarized.

5 Conclusions

This chapter moved from the acknowledgment of the profound evolution that has characterized the operational models of vehicle sharing in the last decade. Though the core idea on which vehicle sharing is based remained the same—i.e., replacing private ownership of cars with the access to a mobility service—both the literature and the practice provide a very diversified picture of how this idea has been deployed in new services through the years. This evolution has been clearly informed by the emerging new technological opportunities, ICT and e-mobility in

particular, and the change in the market demand, with users that are more sensible toward the issues of environmental protection, and also more used to the idea of really considering mobility as a service (i.e., not necessarily associating it with car ownership).

With this background, this chapter has drawn a picture of different car-sharing service configurations, first presenting the state-of-the-art literature and then introducing the innovative configurations developed with the Green Move project: the condominium car sharing; the network of services; and the new business fleet. These configurations have been designed based on the analysis of 1) the potential mobility profiles to whom a vehicle-sharing service could answer and 2) the mobility performance that is particularly relevant in connection with such profiles.

In conclusion, we discuss the main limitations of this work that open the way to future research. First, it is worthy of mentioning that the proposed configurations aim to answer to a potential demand for mobility that is associated with some specific mobility profiles. The identification of the mobility profiles and the relevant vehicle-sharing performance has been carried out based on the literature review. Hence, they are quite general in scope. Then, the Green Move configurations were developed posing particular attention to those mobility profiles that are somehow coherent with those expected in a large city. However, the same methodological approach could be adopted in order to develop different service configurations in areas that are characterized by a different mobility demand. The second aspect that is worthy of mentioning is that, in this chapter, limited attention has been given to peer-to-peer vehicle sharing. This is an interesting possible development that is coherent with the emerging paradigm of the sharing economy, and it is addressed in Chap. 5.

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