# Keeping Up with the Development of Vehicle-Sharing Services

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# Keeping Up with the Development of Vehicle-Sharing Services: a Comprehensive Analysis of the Offer in Paris, Madrid and Hamburg

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## ABSTRACT

Vehicle-sharing services are a well-identified category among shared mobility services. However, the services that emerged of their rapid development in European cities are sometimes very different one from another. Understanding the development and characteristics of these new services and the strategies of the actors that provide them can help urban mobility actors take these services into account when they define or implement their urban mobility policies.

This article is based on a comprehensive census of the vehicle-sharing services active in Paris, Madrid and Hamburg as of May-June 2021. It analyses the service providers, the regulations that apply to the services, and the operational features of the services. Features studied includes indicators on the density of vehicles and on the prices of the services. This allows to define three broad categories of services that share similar characteristics: public bike-sharing services, micromobility vehicle-sharing services, and carsharing services. We find that each category is similarly developed in each of the three cities of the study despite differences in the regulations.

The results presented provide the basis for more detailed study focused on the relations established between vehicle-sharing services and other actors of urban mobility, and on the use of the infrastructure by vehicle-sharing services.


**Keywords:** Vehicle-sharing, Shared mobility, Bike-sharing, Carsharing, Scooter-sharing, Motosharing, Regulation, Classification

## INTRODUCTION

The last decade has seen the emergence of a great diversity of new mobility services, fueled in part by information and communication technologies (ICT) – and singularly by the smartphone – (*1*) but also influenced by electric mobility (*2*). These new services are often operated by actors that are new to the mobility sector, and rely on new business models. Their rapid development has raised new issues, often specific to these new services, such as their use of the urban space and infrastructures, the safety of the users, the regulation of the offer, or their funding for instance. Indeed, their development has generally occurred outside of the traditional framework of mobility policies: they can neither be considered as a form of public transit nor are they personal vehicles. For this reason, they have come to be known as « paratransit » (*3*), or « shared mobility » because they provide the users with « the shared use of a vehicle, bicycle, or other low-speed mode that enables users to have short-term access to transportation modes on an "as-needed" basis » (*4*).

The International Transport Forum's Corporate Partnership Board noted in 2016 that shared mobility offers significant environmental advantages, and that public authorities « must guide the deployment of shared mobility systems and anticipate their impacts » (*5*). The broad category of shared mobility includes services as different as carpooling, e-scooter sharing or demand-responsive transport for instance. Understanding the development and characteristics of these new services and the actors, strategies and policies that shape them is the first step towards making them contribute positively to the mobility system as a whole and to the more general goal of connectivity and sustainability.

Various attempts at classifying these new services have been made but none has been widely adopted yet. Boutueil et al. (*6*) have discussed different existing classifications, and have conducted a worldwide census of digital platforms for shared mobility. Continuing in the same direction, and in the view of « building a bottom-up, yet systematic typology of such services » (*7*), this paper focuses specifically on vehicle-sharing services among all shared mobility services. Vehicle-sharing services constitute a well-identified type of shared mobility services. They can be defined by expanding the definition of carsharing established e.g. by Ciari et al. (*8*): vehicle-sharing services provide « a fleet of vehicles that can be shared by several users, who can drive it when they need it, without having to own one ».

Vehicle-sharing systems can be traced back to several decades, mainly in the form of carsharing and station-based bike-sharing (*9, 10, 11*), and recent years have seen an important development of such systems across the globe: it has been possible to identify more than a hundred vehicle-sharing platforms with more than 100,000 downloads on Google Play as of 2020, with services available on every continent (*6*).

Recent literature on vehicle-sharing has mainly focused on the mobility-related behaviors induced by these services or on their impacts on the environment. A study on the origins and destinations of 27 millions carsharing trips in 22 cities shows that these services are used as a complement rather than as a replacement to public transport (*12*). Using carsharing services also reduces car ownership by encouraging resales or delaying purchases (*13*), and a study on the Madrid bike-sharing service BiciMad shows that it is a way to promote cycling (*14*). De Bortoli (*15*) calculates that free-floating e-scooters in Paris emit 109g$CO_2$eq/pkt, half of the emissions coming from the servicing stage, and the other half from manufacturing. Studies on the users of vehicle-sharing services consistently show that they are higher-educated, city-center dwellers, young men, and more prone to drive frequently (*16, 17*). But researches also suggest that there are differences among vehicle sharing-services. A comparative study of a one-way and a round-trip carsharing service in Vancouver shows that they have differentiated impacts on car ownership and use of other modes of transport (*18*). Free-floating services also operate in denser areas than station-based carsharing services (*19, 20*). Another comparative study, this time between a free-floating bike-sharing service, a station-based bike-sharing service, and a bike-lease scheme in Delft shows that the different services are quite different in terms of user groups, motivations and modal shift effects (*21*).

The stream of literature dealing with vehicle-sharing services from the operational perspective is more limited. Several scientific publications have studied specific vehicle-sharing services or groups of

vehicle-sharing services. For example: Shaheen documented the state of the carsharing market worldwide (*22*); Nair studied the Vélib' system in Paris (*23*); Arias-Molinares et al. presented the various vehicle-sharing services operated in Madrid (*24*). Sprei et al. have compared carsharing to other modes of transport: it is generally slower than bike, but faster than walking or using public transport (*25*). Other researches have focused on questions specific to vehicle-sharing services: Tironi detailed how the repairing teams of the Vélib' service dealt with the uncertainty as to how the bikes were actually used and deteriorated (*26*). On the issue of the relocation of the vehicles, Herrmann proposed to integrate real-time data in the simulation models (*27*).

This article will focus on the operation side of vehicle-sharing services. The goal is to study the development of the different vehicle-sharing services and to provide elements about whether and how local governments, mobility providers or other actors of urban mobility can integrate vehicle-sharing services in their respective strategies. In order to understand the implications of existing studies on specific vehicle-sharing services and to inform future studies on vehicle-sharing services, this article adopts a systematic approach of vehicle-sharing services so as to identify different categories among them. To do so, we conduct a study of every vehicle-sharing service currently available in the European cities of Paris, Madrid and Hamburg. For each service, we create indicators based on open-access data relative to: the actors that provide the service, the type of service provided, the operation of the service, its price, and the regulation that applies.

The scope of the article, however, is limited to the context of European metropolises – where the number of vehicle-sharing services is the highest (*6*). Indeed, European metropolises share a common « mobility profile », with similar characteristics such as: efficient mass transit systems, relative low share of trips made by car, developed road infrastructures, high motorization rates, emerging shared modes, high incomes, slow economic and demographic growths (*28*). These characteristics may be important to explain the observed development of urban vehicle-sharing services

Together, the services present in the three cities studied constitute a large and diversified sample of vehicle-sharing services in the context of European cities. Their study allows us to identify different categories of vehicle-sharing services based on the features mentioned. These categories can in turn be used as an analytical framework to conduct a cross-city comparison between Paris, Madrid and Hamburg in terms of vehicle-sharing offer. More broadly, this study should provide the basis for future in-depth studies on the development and regulation of specific vehicle-sharing services in similar contexts.

## METHODS

To build a sample with a significant number of vehicle-sharing services with a limited variation of the mobility profiles of the cities in which they operate, the authors chose a perimeter composed of three comparable European cities which each hosts a significant number of vehicle-sharing services. We conducted a systematic census of every vehicle-sharing service that operated within this perimeter. Incidentally, this method allows for a comparison between the three cities in terms of vehicle-sharing offer and to formulate hypotheses regarding the influence of the mobility profile of the city for the development of vehicle-sharing services.

### Description of the Perimeter: Paris, Madrid and Hamburg

The geographic perimeter chosen for this study is composed of: the Île-de-France Region, the Community of Madrid, and the State of Hamburg. These regions comprise respectively the cities of Paris, Madrid and Hamburg, which are among the ones with the greatest number of vehicle-sharing services worldwide (*6*). We focused on regions rather than municipalities because many services operate in several contiguous municipalities.

Île-de-France and the Community of Madrid are both capital-regions of similar size and population. Hamburg is a city-state with less population: in fact, its population is similar to that of the municipalities of Paris and Madrid. The share of trips made by car and public transit are very similar in the three regions, but Hamburg has a greater share of trips made by bike and a lower share of walking trips compared to the other two regions.

**TABLE 1 General Information on Île-de-France, Community of Madrid and Hamburg**

| Region | **Île-de-France** | **Community of Madrid** | **Hamburg** |
|---|---|---|---|
| Country | France | Spain | Germany |
| Type of government | Region | Autonomous Community | State |
| Number of municipalities | 1,268 | 179 | 1 |
| Transport authority | Region | Region | Metropolitan area (inter-States) |
| Parking authority | Municipality | Municipality | State |
| Population (million inhabitants)[1] | 12.2 (Paris: 2.2) | 6.5 (Madrid: 3.3) | 1.7 |
| Area (square kilometers) | 12,012 (Paris: 105) | 8,030 (Madrid: 604) | 755 |
| Population density (inhabitants per square kilometers) | 1,024 (Paris: 20,641) | 827 (Madrid: 5,266) | 2,585 |
| Disposable income per inhabitants in PPS[2] | 20,600€ | 19,500€ | 23,200€ |
| Modal split 2017/18 (walk/bike/car/public transit) | 40/2/35/22[3] (Paris: 52/3/13/32[4]) | 34/?/39/24[5] (Madrid: 35/?/29/33) | 27/15/36/22[6] |
| Active vehicle-sharing services | 16 | 17 | 18 |

**Definitions and Identification of the Vehicle-Sharing Services Included in the Sample**

Vehicle-sharing services are defined as shared mobility services matching the three following criteria: 1) low-capacity vehicles, 2) user driver, and 3) driver not paid (*6*). In this study, « short-term access » (*4*) to vehicles was interpreted as the possibility to rent vehicles for periods of 1 hour or less, and « as-needed

1 Population change - Demographic balance and crude rates at regional level (NUTS 3) , https://ec.europa.eu/eurostat/databrowser/view/DEMO_R_GIND3$DEFAULTVIEW/default/table
2 Income of private households (PPS per inhabitant, based on final consumption), Disposable income, net, 2018 (https://ec.europa.eu/eurostat/cache/RCI/#?vis=nuts2.economy&lang=en)
3 Île-de-France mobilités/Omnil. *La nouvelle enquête globale transport. Présentation des premiers résultats 2018,* 2010
4 Omnil. *Enquête globale transport. La mobilité en Île-de-France*, 2012
5 Consorcio Regional de Transportes de Madrid. *Encuesta de movilidad de la comunidad de Madrid 2018. Documento sintesis*, 2019
6 infas, DLR, IVT und infas 360 (2020): Mobilität in Deutschland (im Auftrag des BMVI)

basis » (*4*) was interpreted as the possibility to find a vehicle directly in the street, without any intermediary between the user and the vehicle other than technological devices (services that require to go through a rental agency were excluded), and with no mandatory advanced booking. We use the term service to designate a fleet of similar vehicles (bikes, cars, scooters or mopeds) operated in a single area by a single service provider. Thus, a service is city-specific while a provider can operate multiple services in a single city or in several cities.

The list of the vehicle-sharing services active in Paris, Madrid and Hamburg is based on the Worldwide census of shared mobility platforms (*6*), updated in May 2021. Search queries were performed on both Google Play and App Store using a set of keywords related to vehicle-sharing services (e.g. carsharing, bike-sharing, e-scooter, moped). This list of vehicle-sharing services was later complemented by using local or specialized newspaper articles, grey literature and other sources so as to include services that may not have appeared in the search results. Only active vehicle-sharing services as of May-June 2021 were included in the study: for each identified service, we checked for recent activity on its website and/or vehicle availability on its app.

A total of 51 services were identified in the 3 metropolitan areas, for a total of 35 service providers. The peer-to-peer carsharing service Amovens in Spain was not included in the study because users are expected to meet the owner of the car before getting access to it. The carsharing service Ada in Paris was not included albeit its cars are available in the streets because the vehicles need to be rented for at least an entire day. Renault Mobility, which offers 4 station-based cars in Versailles (Île-de-France) was not included because of the very limited scope of the service. The station-based bike-sharing system Nextbike in Norderstedt, near Hamburg, is outside of the limits of the State and was therefore not included. Finally, the vehicle-sharing services Bird (Île-de-France), Bolt (Hamburg) and Bond (Hamburg) were not active at the time of the study (no available vehicles displayed on the apps) and were therefore not included.

Each city had approximately the same number of services available. They also had approximately the same split of vehicle-sharing services by type of vehicles, with Paris having fewer scooter-sharing services and Madrid fewer carsharing services. Overall, there were more services of carsharing and scooter-sharing (respectively 20 and 14 in total) and fewer services of motosharing and bike-sharing (respectively 10 and 7 in total).

**TABLE 2 Vehicle-Sharing Services Identified in Île-de-France, Community of Madrid and Hamburg as of May-June 2021**

| | **Paris and Île-de-France** | **Madrid and Community of Madrid** | **Hamburg** | **Total** |
|---|---|---|---|---|
| **Bike-sharing** | Pony, Lime, Vélib’ | BiciMad, RideMovi | StadtRad Hamburg, Lime | **7** |
| **Carsharing** | Free2Move, Zity, Share Now, Ubeeqo, Communauto, Clem.mobi, Getaround | GoTo, Free2Move, Wible, Share Now, Zity | WeShare, Sixt Share, Flinkster, Greenwheels, Cambio, Share Now, Miles, Getaround | **20** |
| **Scooter sharing** | Lime, Tier, Dott | Spin, GoTo, Movo, Link, Lime, Bird | Dialog, Bird, Tier, Voi, Lime | **14** |
| **Motosharing** | Cityscoot, Lime, Troopy | GoTo, Movo, Acciona Movilidad, Cooltra | Tier, Emmy, Felyx | **10** |
| **Total** | **16** | **17** | **18** | **51** |

## Features Studied, Data Collection and Indicators

The data collected for each vehicle-sharing system covers features relative to: the service providers; the regulation; and the operation of the service. The data collected and the indicators created give some information to assess the actual mobility options that the vehicle-sharing services provide, their impacts on the use of the urban space and on the environment, or the development strategies of the service providers.

### *Data on the Service Providers*

For each identified service, various data on the service provider were collected: location of the headquarters, date of foundation of the company (when a service was transferred from one service provider to another, the date recorded is the date of the foundation of the first service provider that operated in the area), name of the app linked to the service and number of downloads on Google Play, parent company, number of cities and countries where the service provider operates vehicle-sharing services. When the data was not directly available on the website or on the app description of the services, it was complemented by local or specialized newspaper articles, grey literature and other sources.

### *Regulation of the vehicle-sharing services*

Through a review of grey literature and specialized and local newspaper, the authors identified specific regulations that apply in Paris, Madrid and Hamburg for the different vehicle-sharing services identified. These regulations include: fleet caps, yearly fees, authorizations for operations, dedicated parking spaces, charters, labels, and contracts. Due to the fragmentation of local authorities in Île-de-France and the Community of Madrid, and given the observed concentration of services in the central areas of these regions, the authors decided to restrict the analysis of the regulation of vehicle-sharing services in these regions to the regulation that applies on the territory of the city of Paris and of the municipality of Madrid.

### *Indicators on the Operation of the Vehicle-Sharing Services*

For each vehicle-sharing service, in each city of the study, data was collected on: date of launch of the service, models and number of available vehicles, number of stations (when applicable), surface of the operating area of the service, operating model of the service, and price list of each service. This data was collected directly from the service provider (website, app) or from local or specialized press articles when necessary. In particular, the surface of the operating area was either calculated from maps on the service provider's website or app, or in some cases from lists of neighborhoods of operations published by local or specialized press articles. Contrarily to data on service providers, these data are city-specific: if a vehicle-sharing service is available in several cities, the data can be different from one to the other.

Some of the data were then processed to create indicators: an estimation of the mean density of vehicles, and the price of a 20-minute trip. The price was calculated for the cheapest 20-minute trip (in case of dynamic pricing or differentiated price according to the type of vehicle used), with no pause. The trip's duration was chosen to be easy to calculate and to be close to the average time of observed trips in Paris, Madrid and Hamburg : 23, 23 and 29 minutes respectively[7,8,9].

# RESULTS

## Vehicle-Sharing Service Providers and Regulation

7 Île-de-France mobilités/Omnil. *La nouvelle enquête globale transport. Présentation des premiers résultats 2018,* 2010

8 Consorcio Regional de Transportes de Madrid. *Encuesta de movilidad de la comunidad de Madrid 2018. Documento sintesis*, 2019

9 infas, DLR, IVT und infas 360 (2020): Mobilität in Deutschland (im Auftrag des BMVI)

*Service Providers*

A focus on the service providers reveals the diversity of profiles among the companies that operate the identified vehicle-sharing services. Indeed, 4 *global* vehicle-sharing service providers – mainly scooter-and-bike-sharing providers – operate in several dozens of cities worldwide on at least two continental areas, while 8 *city-specific* vehicle-sharing service providers operate in 1 or 2 cities only. 8 *country-specific* vehicle-sharing providers are present in many cities throughout one or two countries: they are mainly (German) carsharing companies. Finally, 15 *regional* vehicle-sharing providers operate in 4 to 90 cities in up to 10 countries.

Many of the carsharing companies identified are controlled by car manufacturers (Share Now, Zity, Wible) or by rental companies (Sixt Share, Ubeeqo). Share Now is part of the Moovel group which also offers ride-hailing, parking and other mobility solutions. The bike-sharing and ebike-sharing service BiciMad is the only vehicle-sharing service in the sample directly operated by the local government, through the Empresa Municipal de Transportes de Madrid. The bike-sharing service StadtRad Humburg and the carsharing service Flinkster are both operated by the Deutsche Bahn, the state-owned railway company (see Appendix).

*Regulation*

In our sample, scooter-sharing services are the most regulated vehicle-sharing services. In all three cities of the study, these services are submitted to fleet caps. In Hamburg, the local government asked each service provider to limit its fleet to 1,000 vehicles. In Paris and Madrid, authorizations for operations were granted through a tendering process: in Paris, 3 service providers were chosen in 2021 with a fleet cap of 5,000 vehicles each; in Madrid, 14 different service providers were selected in 2019 with a fixed number of scooters in each of the 128 neighborhoods of the municipality, for a total of 4,821 scooters.

Madrid is the only of the 3 cities where a fleet cap is required for bike-sharing services. As for scooter-sharing services, authorizations for operations were granted through a tendering process in 2020 for 6 service providers to operate a total of 3,900 shared bikes: 2,000 in the 7 central districts (45 neighborhoods), and 1,900 in the 14 others (83 neighborhoods).

Paris is the only of the 3 cities to make vehicle-sharing service providers pay a yearly fee (variable depending on the total number of vehicles in the fleet): 50 to 65€ per scooter; 20 to 26€ per bike; 60 to 78€ per e-moped; and 120€ to 156€ per non-electric moped. The city of Paris also signed charters with the different bike-sharing (2018), motosharing (2018) and scooter-sharing (2019) service providers.

Carsharing services, for their part, are not subject to fleet caps or yearly fees in any of the cities of the study. In fact, in Paris and in Hamburg, the local governments have created dedicated parking spaces for these services. In Paris, Ubeeqo, Clem.mobi, Getaround and Communauto are part of the city-sponsored Mobilib' scheme which lets them use 1370 charging stations located throughout the city. In parallel, the regional transport authority Île-de-France Mobilités has created the *Île-de-France autopartage* carsharing label which guarantees standards of sustainability and quality of service to users. Zity, Communauto, Clem.mobi and Cityscoot have been granted the label. In Hamburg, the carsharing services are integrated in the Switch multi-modal mobility scheme of the Hamburger Verkehrsverbund, the transport association that regroups the transport operators of Hamburg and the larger metropolitan area. Carsharing service providers can use the parking spaces of the 87 « Switch points » located near Hamburg train stations and throughout the city.

Finally, in Paris, Madrid and Hamburg, station-based bike-sharing services are all organized by local governments. In Paris, Vélib' is organized by a grouping of municipalities of the Paris region; in Madrid, BiciMad is directly operated by the Municipal Transport Company of Madrid which operates the urban buses of the city; in Hamburg, StadtRad Humburg is organized by the city-state.

**TABLE 3 Specific regulations for vehicle-sharing services on the territory of Paris, Madrid and Hamburg**

| | Paris | Madrid | Hamburg |
|---|---|---|---|
| **Bike-sharing** | - Charters<br>- Yearly fees : 20 to 26€/vehicle | - Authorizations for operations<br>- Fleet caps : 3,900 vehicles for 6 service providers in total | - |
| **Station-based bike-sharing** | - Contract with a grouping of municipalities | - Operated by the Municipal Transport Company | - Contract with the city-State |
| **Carsharing** | - Label<br>- Dedicated parking spaces : 1370 charging stations | - | - Dedicated parking spaces : 87 locations throughout the city |
| **Scooter-sharing** | - Authorizations for operation, charters<br>- Fleet caps : 5,000 vehicles for each of the 3 service providers<br>- Yearly fees :<br>50 to 65€/vehicle | - Authorizations for operation<br>- Fleet caps : 4,821 vehicles for 14 service providers in total | - Fleet caps : 1,000 vehicles per service provider |
| **Motosharing** | - Charters<br>- Yearly fees :<br>60 to 78€/vehicle (electric)<br>120 to 156€/vehicle (non-electric) | - | - |

## Conception and Operation of the Vehicle-Sharing Services

*Duration of Operation*

Based on the duration of operation of the vehicle-sharing services, it is possible to identify different waves of creation of services. They are not necessarily city-specific. However, this description does not include the services that have ceased their operations.

- The first carsharing services were created more than 15 years ago. They are all station-based and round-trip;
- Station-based bike-sharing systems were created between 2007 and 2014;
- In the 3 cities of the study, 6 motosharing services were created between 2016 and 2018.
- 3 free-floating carsharing services were created in Madrid between 2015 and 2017, while in Paris and Hamburg – which each had 1 free-floating carsharing service since 2015 and 2011 respectively –, 5 carsharing services were created between 2018 and 2019.
- Most scooter-sharing services were created between June 2018 and April 2019 in Paris and Madrid, while in Hamburg they were mostly created during the second semester of 2019.
- The end of 2020 and beginning of 2021 has seen the creation of all types of vehicle-sharing services, including 2 free-floating bike-sharing services (Paris and Hamburg).

The years 2018 and 2019 have seen the most launches of vehicle-sharing services still in operation with 21 new services launched overs these 2 years. The first months of 2021 have seen the launch of 8 vehicle-sharing services in all three cities studied. The low mean duration of operation of

most types of vehicle-sharing services of the sample is the consequence of both the rapid development of vehicle-sharing services and the short life-span of many of them. Indeed, 13 vehicle-sharing services identified as operational in the three cities studied in May 2020 by the Worldwide census of shared mobility platforms (*6*) were not in operation anymore at the time of this study (May-June 2021)1.

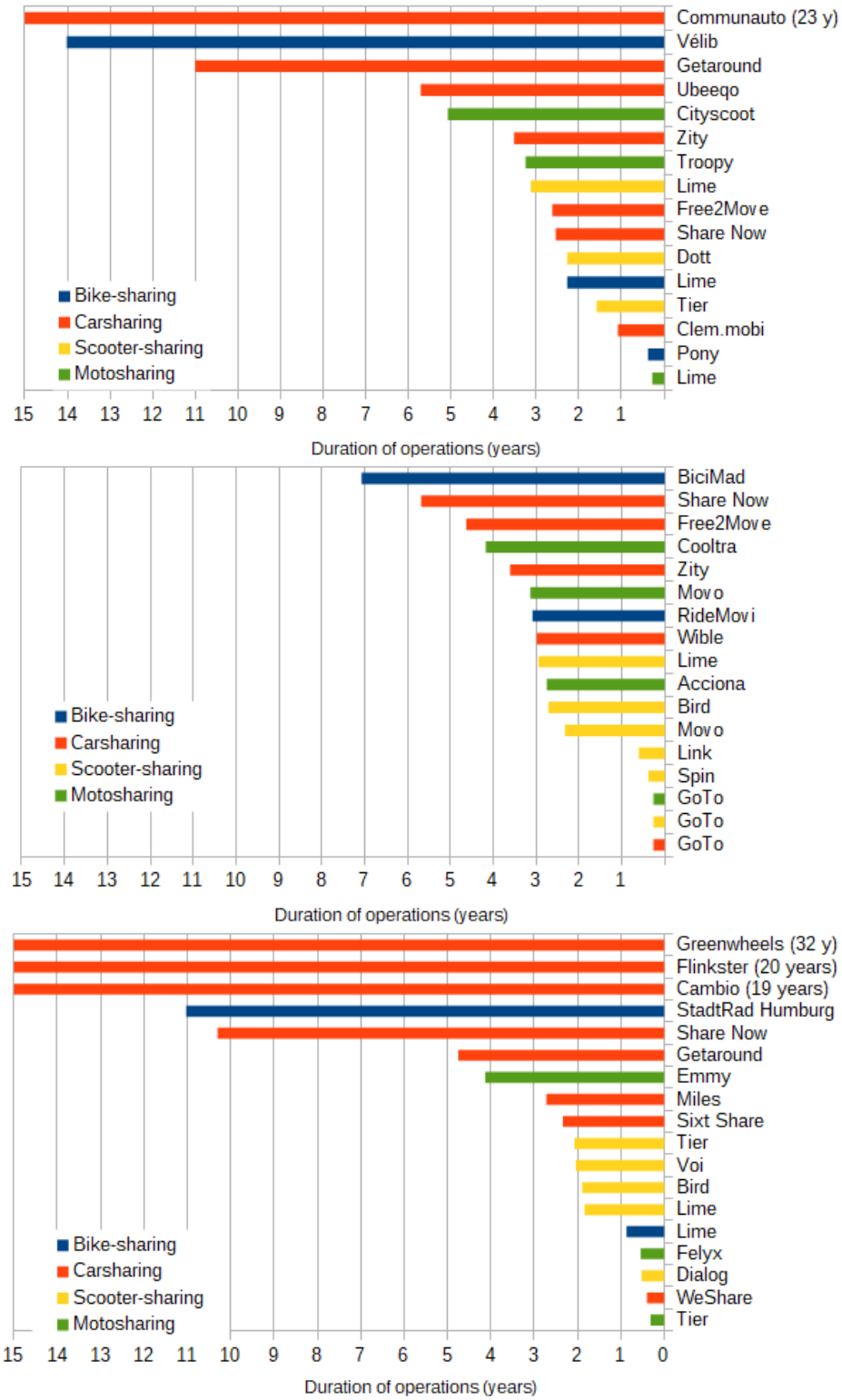


**Figure 1 Duration of operation of the vehicle-sharing services active as of May-June 2021 in Paris (top), Madrid (middle) and Hamburg (bottom), in years**

*Operating Models*

Vehicle-sharing services can be operated in a variety of ways, which can affect significantly how the service is used and how it can be regulated (*18*). The service provider can allow one-way trips, which means that the vehicle can be returned anywhere in a large operating area defined by the service provider, or else restrict the user to round-trips, which means that the user needs to bring the vehicle back to where they started using it. Vehicles can be based in designated stations – reserved space managed by the service provider – or can be free-floating: in this case, users can find and return the vehicles on parking spaces available to the general public (where necessary, the company usually assumes the parking fee after the user ends its trip).

All 15 scooter-sharing services and all 10 motosharing services in the sample are one-way, free-floating services. The fleets exclusively include electric vehicles, with the exception of the Troopy motosharing service in Paris which offers a fleet of 3-wheeled heat-engine mopeds.

Bike-sharing services exist in station-based or free-floating versions. Paris, Madrid and Hamburg each have one station-based bike-sharing service, as well as one or two free-floating bike-sharing services. The fleets of the 5 free-floating bike-sharing services in the sample are fully electric. StadtRad Humburg, the station-based bike-sharing service of Hamburg, offers 3,100 mechanical bikes but also 20 electric cargo bikes. In Madrid, BiciMad offers around 2,400 mechanical station-based bikes and around 500 electric free-floating bikes. In Paris, around 40 % of the 20,000 Vélib' bikes are electric, and both the mechanical and the electric bikes of the fleet are station-based.

8 of the 20 carsharing services in the sample are station-based and are limited to round-trips. Among them, the Getaround services are peer-to-peer: individuals make the car they own available by installing a device on their vehicle that allows the users of the service to unlock and use the vehicle. In Madrid, all 5 carsharing services are free-floating, and the fleets are fully electric (or plug-in hybrid for Wible). By contrast, only 4 of the 7 Parisian carsharing services and 1 of the 8 Hamburgian carsharing services have fully electric fleets.

*Operating Areas and Fleets*

23 of the 33 vehicle-sharing services for which it was possible to collect information have an operating area between 50 and 100 sq.km. In particular, 11 of the 15 carsharing services have an operating area between 75 and 100 sq.km. In Madrid, 7 out of 14 vehicle-sharing services have an operating area between 50 and 70 sq.km, which is approximately the area within the M-30 ring-road. In Paris, several vehicle-sharing services are concentrated in the territory of the municipality, also materialized by a ring-road. With an area of approximately 400 sq.km, Vélib' has the largest operating area (Madrid scooter-sharing service Link displays an operating area of 350 sq.km but its vehicles are de facto concentrated in a much smaller central area). 3 scooter-sharing services and 2 bike-sharing services have an operating area of less than 50 sq.km.

No carsharing service has a fleet of more than 1,200 vehicles, whereas 7 bike-, scooter- or moto-sharing services have fleets of more than 3,000 vehicles. Vehicle-sharing services of all types have fleets of 500 vehicles or less. Vélib' is the largest vehicle-sharing service in terms of vehicles by far, with 20,000 bikes in its fleet. The 2 scooter-sharing services for which we have data in Paris have 5,000 scooters in their fleets, while in Madrid, the 3 scooter-sharing services have less than 400 scooters, which can be explained by the regulation and the tendering process of each city.

Density of vehicles varies greatly, from less than 0.2 vehicle/sq.km for Greenwheels in Hamburg to 103 vehicles/sq.km for StadtRad in Hamburg. In particular, round-trip carsharing services have the lowest densities: they do not require as strong a network effect as one-way carsharing services to operate since vehicles have to be returned to their initial location. The density of vehicles of bike-sharing services – and in particular station-based bike-sharing services – are significantly higher than the density of other vehicle-sharing services: all 4 of the services for which we have data have a density greater than 20 vehicles/sq.km.

**TABLE 4 Fleets and Operating Areas of Vehicle-Sharing Services in Paris, Madrid and Hamburg.** All values for semester 1 2021 except Lime: semester 2 2020. Values for round-trip vehicle-sharing services are underlined.

| | Paris | | | | Madrid | | | | Hamburg | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bike-sharing** | **Service** | **Vehicles** | **Area (sq.km)** | **Density (veh./sq.km)** | **Service** | **Vehicles** | **Area (sq.km)** | **Density (veh./sq.km)** | **Service** | **Vehicles** | **Area (sq.km)** | **Density (veh./sq.km)** |
| | Vélib' | 20,000 | 400 | 50 | BiciMad | 3,000 | 60 | 50 | StadtRad Humburg | 3,100 | 30 | 103 |
| | Lime | 5,000 | - | - | RideMovi | - | - | - | Lime | 500* | - | - |
| | Pony | 500 | 25 | 20 | | | | | | | | |
| **Carsharing** | Share Now | 600 | 85 | 7 | Zity | 800 | 100 | 8 | Share Now | 1,200 | 95 | 13 |
| | Zity | 500 | 95 | 5 | Share Now | 600 | 85 | 7 | Miles | 1,000 | 80 | 13 |
| | Free2Move | 350 | 90 | 4 | Wible | 500 | 65 | 8 | WeShare | 800 | 85 | 9 |
| | Communauto | 200 | 130 | 2 | Free2Move | 415 | 80 | 5 | Cambio | 80 | 85 | 1 |
| | Ubeeqo | 125 | 85 | 1 | GoTo | 300 | 60 | 5 | Greenwheels | 50 | 280 | 0,2 |
| | Getaround | - | country | - | | | | | Sixt Share | - | 85 | - |
| | Clem.mobi | - | 85 | - | | | | | Flinkster | - | country | - |
| | | | | | | | | | Getaround | - | country | - |
| **Scooter-sharing** | Lime | 5,000 | - | - | GoTo | 400 | 60 | 7 | Dialog | - | 100 | - |
| | Tier | 5,000 | - | - | Movo | 150 | 15 | 10 | Voi | - | 20 | - |
| | Dott | - | 85 | - | Spin | 100 | 15 | 7 | Bird | - | - | - |
| | | | | | Link | - | 350 | - | Tier | - | - | - |
| | | | | | Lime | - | - | - | Lime | - | - | - |
| | | | | | Bird | - | - | - | | | | |
| **Motosharing** | Cityscoot | 3,900 | - | - | Movo | 1,100 | 55 | 20 | Tier | 100 | - | - |
| | Lime | 1,000 | - | - | GoTo | 450 | 60 | 8 | Emmy | - | 65 | - |
| | Troopy | 250 | 110 | 2 | Cooltra | - | 65 | - | Felyx | - | - | - |
| | | | | | Acciona | - | 75 | - | | | | |

*Prices*

Most of the vehicle-sharing services in the sample charge by the minute. Station-based bike-sharing services charge the user for a period of 30 minutes or 1 hour. 5 carsharing services in Hamburg and Paris also charge by the hour. All scooter-sharing services charge an unlocking fee at the start of each ride, usually 1.00€. Cambio and Communauto are the only vehicle-sharing services in the sample for which a registration is mandatory to use the service. Vélib', StadtRad Humburg and BiciMad offer cheap subscriptions (respectively 0€, 5€ and 25€ per year). For these 5 services, it is the cost of a trip with a subscription that is plotted (without a subscription, a 20-minute trip using Vélib' or StadtRad would require a day ticket at respectively 5€ and 15€). Other than these, the majority of the services studied do not provide subscription packages.

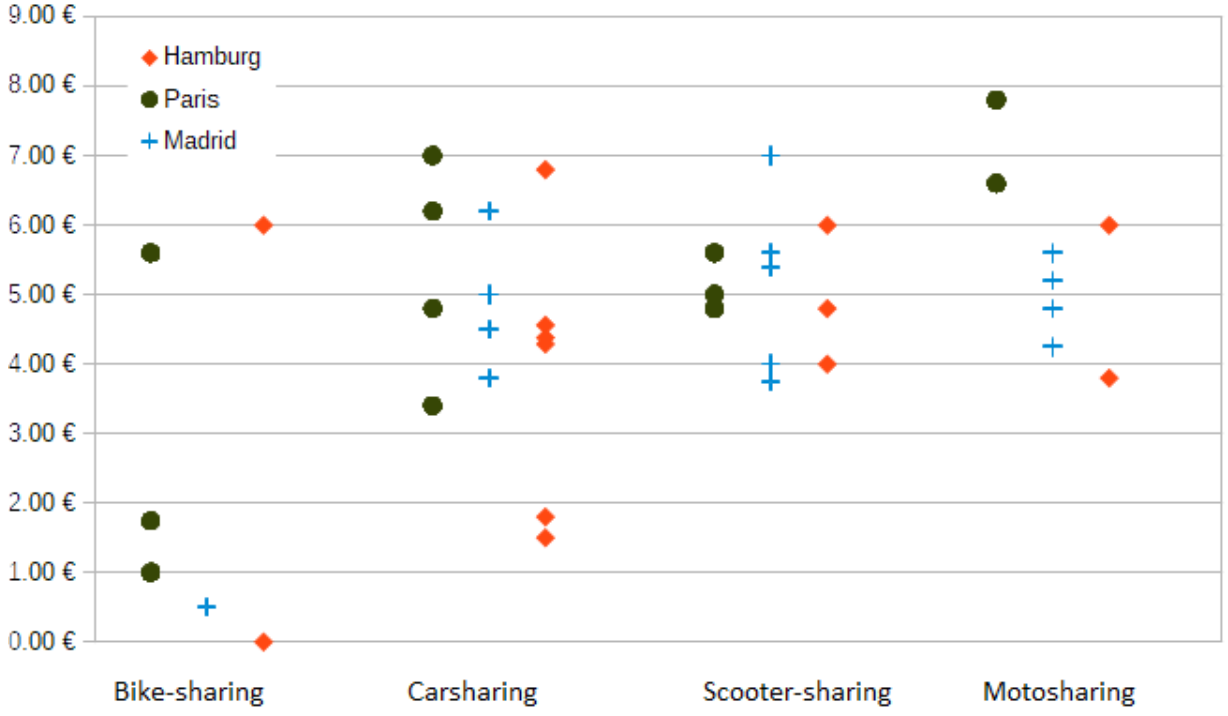


**Figure 2 Price of a 20-minute trip* for various vehicle-sharing services in Paris, Madrid and Hamburg** (*the carsharing services Miles and Cambio in Hamburg price the trips according to the distance traveled. The price was calculated for a 6-kilometer trip. The bike-sharing service StadtRad Humburg does not charge trips of less than 30 minutes for users with a 5€/year subscription)

For most of the vehicle-sharing services of the sample, the price of a 20-minute trip, be it with a car, an e-scooter, an e-bike or an e-moped, ranges between 3.50€ and 7.00€. Exceptions include the station-based bike-sharing services Vélib', BiciMad and StadtRad Humburg that offer 20-minute rides at less than 1€ for users with a (cheap) yearly subscription, as mentioned earlier. In Hamburg, the carsharing services Flinkster, Share Now and Sixt Share also have starting prices at between 1.50€ and 1.80€ for a 20-minute trip; however, Share Now and Sixt Share both use dynamic pricing and the actual cost of a trip may be higher in most cases.

The prices of each service are similar across cities, with the exception of motosharing services that are significantly more expensive in Paris.

These prices can be compared to the price of a public transit ticket. In Paris, the regular price for a trip using bus, tramway or metro services in the city-center (where most of the vehicle-sharing services are concentrated), is 1.90€. In Madrid, the price of a bus ticket in the Municipality of Madrid is 1.50€, and

a metro ticket costs 1.50€ up to 5 stations and 2.00€ for more than 10 stations. In Hamburg, the price of a single ticket for public transit is between 1.80€ and 2.40€. Thus, most vehicle-sharing services are significantly more expensive than public transit tickets.

## CONCLUSIONS

The various indicators presented above allow us to identify 3 broad categories of services:

- *Public bike-sharing services*. Only 3 bike-sharing services in the sample fall in this category: Vélib', BiciMad and StadtRad Humburg. They are each organized directly by the local governments. Most other indicators make them singular: they are station-based, offer non-electric bicycles, and have large fleets. They are much cheaper to use than other vehicle-sharing services provided the user has a subscription. Each of the three mentioned services is specific to its city, and they have all been in operation for 7 to 14 years.
- *Micromobility vehicle-sharing services*. They are characterized by the use of electric vehicles, whether e-bikes, e-scooters or e-mopeds and offer free-floating services. They offer no or very limited subscription options and the trip is charged by the minute, often with an unlocking fee. Their operating areas are small, often limited to the city-center. They may have small or large fleets. Many of the micromobility vehicle-sharing service providers are global, but some are regional or even city-specific. They are strongly regulated in all three cities of the study, be it with fleet caps, authorizations of operations, or yearly fees. Most of the micromobility vehicle-sharing services currently in activity are less than 3 years old.
- *Carsharing services*. This category is defined primarily through the vehicle offered and is more diverse than the two previous categories. Some carsharing services share several characteristics with micromobility vehicle-sharing services: free-floating electric vehicles charged by the minute within limited operating areas. However, almost all of them have been operated for more than 3 years, and fleets are rather limited in size. Furthermore, they are not subject to the same kind of regulations as other micromobility vehicle-sharing services. Other carsharing services are closer to short-term car-rental services. These are often station-based, limited to round-trips, and charge by the hour. Their vehicles are not necessarily electric. Many of these carsharing services have been operated for more than a decade. Their service providers generally operate throughout one or two countries. Carsharing services generally enjoy dedicated parking spaces in the cities where they operate.

Interestingly enough, all three categories of vehicle-sharing services are similarly developed in each city. Paris, Madrid and Berlin each have numerous micromobility vehicle-sharing services of all types; they each have one public bike-sharing service; and they each have several carsharing services. However, all of Madrid carsharing services are closer to micromobility vehicle-sharing services, while Hamburg carsharing services are closer to short-term car rental services.

### *Prospects for future research*

The rapid development of shared mobility in general and vehicle-sharing services in particular takes multiple forms, and new developments can be expected. Understanding their different characteristics can help local governments and other actors of urban mobility discriminate between the many new services that are emerging, take them into account in their mobility and urban management strategies, and define differentiated public policies for each category of service according to their characteristics.

The first exploratory results presented here should be complemented by further studies in order to clarify the role played by public policies in the shaping of the actual vehicle-sharing offer. This could be achieved by looking at the recent development of vehicle-sharing services over time through a diachronic

analysis, or by comparing the cases studied presented here to other cities and urban areas with fewer vehicle-sharing services or with different mobility profiles, such as developing cities or more car-oriented cities (*28*). Such studies could also help update the work on the successive « generations » of bike-sharing services (*10*) and could expand this work to other vehicle-sharing services. It would also be interesting to compare the categories established here from the operational perspective with the actual use that is made of these services, and with their respective users' profiles and mobility behaviors.

Finally, the analysis of the regulation of vehicle-sharing services could be complemented by looking more closely at the relations that are established between vehicle-sharing service providers and other mobility actors, e.g., public authorities, public transit operators or other mobility service providers. In particular, ticketing policies, accessibility of a service through a partner's mobility application, or price integration of vehicle-sharing services with other mobility services can be powerful tools for managing the development of vehicle-sharing services. Indeed, Mobility-as-a-Service, defined as "a new paradigm that focuses on providing a single platform for combining all the existing transportation options and provides them to the customers as an integrated and simple solution" (*29*), has been mentioned as a way both to increase the performance of shared mobility services, and to make them an integral part of public authorities' mobility strategies. Vehicle-sharing services also establish relations with mobility actors and urban management actors in general through their use of mobility infrastructures (road, cycle lanes, parking spaces etc.). Thus, infrastructures should also be an element of focus in future studies on the development of vehicle-sharing services.

## AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: V. Boutueil, T. Mangeart; data collection: T. Mangeart, analysis and interpretation of results: T. Mangeart, V. Boutueil. Author; draft manuscript preparation: T. Mangeart, V. Boutueil. All authors reviewed the results and approved the final version of the manuscript.

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# APPENDIX

## APPENDIX 1 Profiles of the vehicle-sharing providers present in Paris, Madrid and Hamburg

| Vehicle-sharing provider | Date founded (HQ) | Link with other companies | Type(s) of vehicles shared | Number of cities | Number of countries |
|---|---|---|---|---|---|
| | | ***City-specific vehicle-sharing providers*** | | | |
| BiciMad | 2014 (Spain) | Municipality-owned company | bike | 1 | 1 |
| Dialog | 2020 (Germany) | | scooter | 1 | 1 |
| Movo | 2017 (Spain) | | moped/scooter | 2 | 1 |
| Troopy | 2018 (France) | | moped | 1 | 1 |
| Vélib' | 2014 (France) | | bike | 1 | 1 |
| WeShare | 2015 (France) | Volkswagen subsidiary | car | 2 | 1 |
| Wible | 2018 (Spain) | Kia-Repsol joint-venture | car | 1 | 1 |
| Zity | 2017 (Spain) | Renault-Ferrovial joint-venture | car | 2 | 2 |
| | | ***Country-specific vehicle-sharing providers*** | | | |
| Cambio | 2000 (Germany) | | car | | 2 |
| Clem.mobi | 2010 (France) | | car | | 1 |
| Communauto | 1999 (Canada) | | car | 17 | 2 |
| Flinkster | 2001 (Germany) | Deutsche Bahn subsidiary | car | | 2 |
| Greenwheels | 1995 (Netherlands) | | car | | 2 |
| RideMovi | 2017 (Italy) | | bike/scooter | 17 | 2 |
| Sixt Share | 2019 (Germany) | Sixt subsidiary | car | 11 | 2 |
| StadtRad Humburg | 2000 (Germany) | Deutsche Bahn subsidiary | bike | 40 | 1 |
| | | ***Regional vehicle-sharing providers*** | | | |
| Acciona Movilidad | 2019 (Spain) | Acciona subsidiary | moped | 8 | 2 |
| Cityscoot | 2014 (France) | | moped | 4 | 3 |
| Cooltra | 2006 (Spain) | | moped | 6 | 3 |
| Dott | 2018 (Netherlands) | | scooter | 12 | 5 |
| Emmy | 2015 (Germany) | | moped | 5 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Felyx | 2016 (Netherlands) | | moped | 11 | 3 |
| Free2Move | 2013 (Geramny) | Stellantis subsidiary | car | 5 | 4 |
| GoTo | 2008 (Israel) | | car/bike/moped/ scooter | 8 | 3 |
| Link | 2013 (USA) | Superpedestrian subsidiary | scooter | 25 | 5 |
| Miles | 2016 (Germany) | | car | 5 | 1 |
| Pony | 2017 (France) | | bike/scooter | 8 | 3 |
| Share Now | 2019 (Germany) | BMW-Daimler joint-venture | car | 16 | 8 |
| Tier | 2018 (Germany) | | scooter/bike | 90 | 10 |
| Ubeeqo | 2007 (France) | Europcar subsidiary | car | 11 | 5 |
| Voi | 2018 (Sweden) | | scooter | 56 | 10 |
| | | ***Global vehicle-sharing providers*** | | | |
| Bird | 2017 (USA) | | scooter/bike | 79 | 13 |
| Getaround | 2010 (USA) | | car | | 9 |
| Lime | 2017 (USA) | | scooter/bike/moped | 142 | 28 |
| Spin | 2016 (USA) | Ford subsidiary | scooter/bike | 67 | 4 |

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