



Shared mobility development as key for prompting mobility as a service (MaaS) in urban areas: The case of Madrid



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ARTICLE INFO

Keywords:

Shared mobility
Mobility as a Service
MaaS
Madrid
Qualitative case study

ABSTRACT

In order to implement Mobility as a Service (MaaS), two main conditions are required: a consolidated public transport system and a varied shared mobility offer. Our study explores the latter condition in the case of Madrid. Through the Multi-Level Perspective framework, emerging shared mobility operators and their service characteristics are diagnosed, in order to explore how this is influencing MaaS developments at the niche level. Our findings show that Madrid has more than 30 services available and an approximate total fleet of almost 30 thousand vehicles, managed by 29 different operators. This dynamic ecosystem of mobility options is facilitating MaaS, as users begin to find it difficult when navigating through all the different applications raising users' and authorities' interest on the subject. However, although there are at least three ongoing MaaS initiatives in the city, there is no collaboration between them. The current state of cooperation supports what other authors have established as one of the main challenges to MaaS' feasibility: poor governance frameworks for MaaS.

1. Introduction

Urban population is constantly growing, and so are pollution levels in most cities (World Bank, 2017). Gross estimates show that in the world's 30 largest megacities, paralyzed traffic flows generate an annual cost of more than USD 266 billion (Rolang Berger Strategy Consultants, 2014). Private vehicles' attractiveness resides in offering door-to-door mobility at any time needed, and in a comfortable manner (for carrying children, heavy objects, groceries, etc.). Hence, new strategies that could help to reduce automobile dependency are urgently needed (Machado et al., 2018). Alternatives to the car should efficiently cover last-mile trips and be as comfortable and flexible as needed. This idea seemed fairly difficult years ago, but collaborative economy and disruptive technological advances are favouring the emergence of new shared mobility services that could promote intermodality (feeding massive transit) and cover less-served areas.

With cities promoting intermodality and the rapid development of electromobility, shared mobility has drawn great attention, especially with the rise of car-sharing, bike-sharing, and more recently, moto-sharing, also known as “moped-style scooter sharing” (Cohen and Shaheen, 2016), and scooter-sharing services. Shared mobility has been defined as the short-term access to shared vehicles according to the user's needs and convenience, instead of requiring vehicle ownership

(Cohen and Shaheen, 2016; Shaheen and Cohen, 2020, 2019). Shared mobility services can be roundtrip; one-way station-based services (vehicle is returned to a different designated station location); and one-way free-floating services (vehicle can be returned anywhere within a geographic area). For example, many car rental services offer roundtrip services because they cover long distances (inter-urban trips), mainly targeting business and leisure purposes. On the other hand, one-way services (free-floating or station-based) are usually services for short urban trips and targeting work/study/errand purposes (Cohen and Shaheen, 2016) (see Fig. 1). In general, scooter-sharing and bike-sharing modes serve for last-mile trips (short distances) feeding public transport, while moto sharing and car sharing are mainly oriented toward serving door-to-door needs (medium- and long-trip distances).

Moreover, shared mobility operators are usually private initiatives that offer their mobility services through an application. Today, with the fast development of information and communication technology (ICT), we can find more than 60,000 travel apps on Google Play (Li & Voegelé, 2017) and this numbers will continue to grow, making it difficult for users to navigate through the plethora of applications (Matyas, 2018). Consequently, the idea of servicizing mobility by integrating all services into one unique spot has raised interest, and it has come to be known as Mobility as a Service (hereinafter, MaaS).

MaaS is defined as a type of service that, through a joint digital

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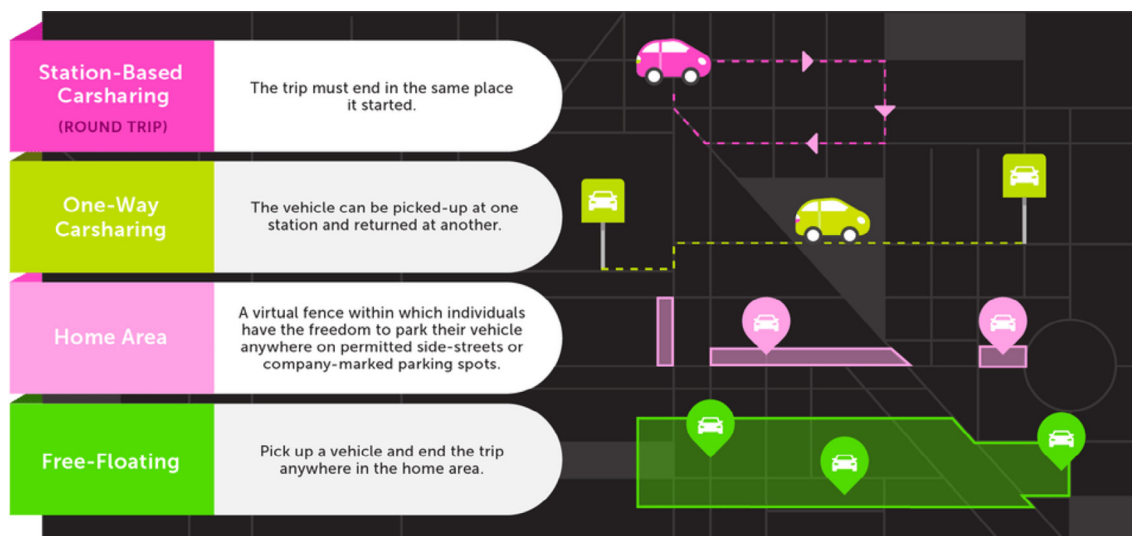


Fig. 1. Type of shared mobility services (station-based vs. free-floating) in the case of car sharing. Source: (López-Iglesias, 2018).

channel, enables users to plan, book and pay for multiple types of mobility services (Smith and Hensher, 2020). MaaS promises to integrate all means of transport into one single application: existing, traditional public transport and new, emerging shared mobility services (Fioreze et al., 2019). The resulting integration of all mobility services is precisely the “bet” on MaaS, as it will cover all transport needs required to substitute a private vehicle.

However, possible MaaS developments could only take place in cities that have *at least* two basic conditions: 1) a robust public transport system and 2) a growing and diverse shared mobility offer (Li and Voegelé, 2017). The latter is the subject of this paper, which aims to explore the shared mobility offer in Madrid and analyse how this offer is playing a key role in prompting MaaS developments in the city. Our hypothesis is that Madrid, like many European cities, has a good public transport system (condition 1), but it is also flooded with new, multiple and diverse shared mobility services (condition 2, which is not yet so common in the European context). This second condition is what differentiates Madrid from other cities, making it a potential candidate for MaaS developments.

As many authors have already established, there is a need to develop more MaaS pilots, and in different contexts, in order to truly anticipate its possible impacts, which are yet uncertain due to a lack of empirical evidence (Aapaoja, et al. 2017; Kamargianni, et al., 2016; Smith, et al., 2019; Smith et al., 2018a,2018b). Therefore, our case study contributes to creating a more solid literature base in MaaS pilots in geographical contexts other than Nordic countries; in this case, Spain, helping policy planners to grasp the complexity of the concept (Liimatainen and Mladenovic, 2018; Mulley and Kronsell, 2018).

The rest of the paper is structured into four sections. Section 2 describes MaaS literature review findings and the analytical framework selected for the case study. Next, materials and methods used are described in section 3, followed by Madrid’s diagnosis of shared mobility in section 4. Finally, in section 5, we present discussions and draw conclusions regarding MaaS developments in Madrid, as well as future steps.

2. MaaS literature and analytical framework

MaaS is topical in scientific literature (Utriainen and Pöllänen, 2018). Due to its recent nature, a first line of research was focused on the architecture of the concept (Jittrapirom et al., 2017; Liimatainen and Mladenovic, 2018; Utriainen and Pöllänen, 2018) and classification of MaaS (Kamargianni et al., 2016; Lyons, et al., 2019; Sochor, et al., 2017). Others are more interested in the organizational structures and

business models to implement MaaS (Hensher, 2017; Merkert, et al., 2019; Meurs, et al., 2018; Polydoropoulou et al., 2019; Wong et al., 2019). A third research path aimed explore demand and travel preferences from recent MaaS pilots in urban areas (Sochor et al., 2016; Strömberg et al., 2018), as well as rural or suburban areas (Aapaoja et al., 2017; Eckhardt et al., 2018; Geurs et al., 2018; Mulley et al., 2018; Wright et al., 2019). Last but not least, scholars have also studied governance issues for MaaS to be feasible, identifying barriers and enabling factors (Smith et al., 2019), in an attempt to anticipate some of its possible impacts (Becker et al., 2019; Jittrapirom et al., 2018a; Pangbourne et al., 2019; Smith et al., 2018a,2018b), exploring regulation challenges (Hirschhorn et al., 2019; Karlsson et al., 2016; Li & Voegelé, 2017; Mukhtar-Landgren & Smith, 2019; Surakka et al., 2018) or stakeholder viewpoints (Audouin & Finger, 2018; Jittrapirom et al., 2018b; Polydoropoulou et al., 2018; Sochor et al., 2015). This last line of research (governance-related) is more developed, as empirical evidence from MaaS pilots is still lacking, and also because it seems to be the main challenge (not technology) to constructing a pathway for MaaS to be feasible (Docherty, et al., 2018; Pangbourne, et al., 2019).

Thus, based on these previous studies, we continue on the governance path and draw on transition theory using the Multi-Level Perspective (MLP) framework, as other authors have done (Audouin and Finger, 2018; Pangbourne et al., 2019). The MLP provides a framework within which transition can be understood as a process in which a socio-technological regime remains in place over time, while new innovation processes occur at the niche level (in this case, shared mobility services and MaaS developments in Madrid), and eventually from pressures from the external landscape (e.g., climate change, technological solutions and new generations’ lifestyles), lead the innovation to become the new regime (Geels, 2012; Geels and Schot, 2007).

3. Methodology

To address MaaS’ development in Madrid, we selected a qualitative case-study approach because, as Pangbourne et al., (2019) advocated, this is suitable to understand new phenomena. The type of case study is exploratory, because it analyses an intervention with no clear single set of outcomes (Baxter and Jack, 2008). In order to carry out the case study, we followed the process illustrated in Fig. 2. In the previous sections, we described the research question addressed (Is the shared mobility offer in Madrid facilitating MaaS?), the type of study selected (case-study research), the analytical framework used (Multi-Level Perspective) and findings from the scientific MaaS literature reviewed

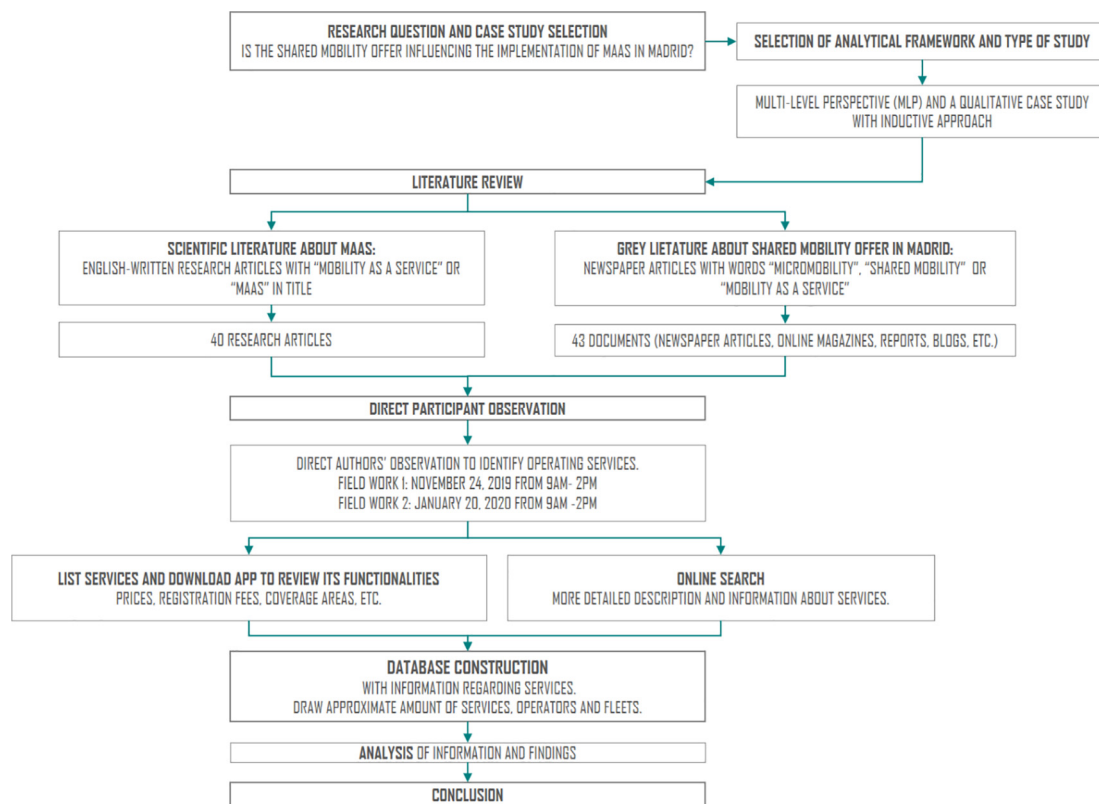


Fig. 2. General case-study research methodology as a process. Source: the authors.

(MaaS lines of research).

In this section, we will support the selection of Madrid as case study and its main characteristics. We then explain the process of literature review (scientific and grey), as well as the data collected to construct the database that backed our findings.

3.1. Case study selection: Madrid

The authors made an information-oriented selection of Madrid as the case study, because “it is useful to maximize the utility of information from small samples and single cases and the selection is based on expectations about the information content” (Flyvbjerg, 2006). The authors are residents in Madrid and could carry out field work with direct observation, and also had good access to the materials used.

Regarding Madrid’s main characteristics, it is a city with a great diversity of land use and high densities of population and employment. Its Metropolitan Region is home to more than 6 million people, with half located in the Municipality of Madrid. In general, Spain has high digital penetration, with 80% of Spaniards owning a smartphone and 85% being internet users and spending an average of five hours and 20 min online (Hootsuite, 2018). In relation to bank accounts, 80% of Spaniards own one (Hootsuite, 2018). Both technological factors (digital penetration and bank accounts) have been shown to be relevant for MaaS (Li and Voege, 2017; Pangbourne et al., 2019).

Furthermore, Madrid is one of Europe’s cities with the highest level of public-transport use, as well as non-motorised transport, according to the European Commission (2014). The public transport network spreads through metro (13 lines, 300 stations and a 293 km coverage area), suburban rail and city and inter-city buses. It mainly serves the municipal area of Madrid, although in recent years, it has been extended to several other towns in the region (García-Palomares et al., 2018). The latest Mobility Survey conducted by the Consorcio Regional de Transportes de la Comunidad de Madrid in 2014 showed that public

and private transport accounted for 53.2% and 43.1% of trips, respectively (another 3.7% apparently account for other modes), and motorised and non-motorised transport account for 75.4% and 24.6% of trips, respectively, as highlighted by Romanillos (2018). A GIS-approach study published in 2008 also showed that “roughly half the population of the Region of Madrid lived less than 600 m from the railway stations and that practically all have access to bus stops” within the same 600 m-distance threshold (Gutiérrez and García-Palomares, 2008, p. 491). Madrid concentrates 1.29 million jobs and has a great supply of social, educational and cultural facilities, offering various entertainment events and public activities. The weather varies quite dramatically throughout the year, with temperatures commonly over 30 °C in summer and close to 0 °C in winter, and it has a dry climate with one of the lowest precipitation levels in Europe (400 mm/year) (Sevillano, n.d.). Another important characteristic of Madrid is its topography, with the presence of hilly streets close to the river and the constant north–south positive slope (Romanillos, 2018).

The high concentration of a young and diverse population (with bank accounts and smartphones), work/study areas, different social and cultural facilities and relatively good weather and topography are all important factors for the development of shared mobility services and MaaS, as stated by (Pangbourne et al., 2019).

3.2. Data collected and materials used

To collect data, we used the inductive approach with two main sources of information. On one hand, a bibliographic review of scientific and grey literature, and on the other hand, primary data coming from direct participant observation and the exploration of applications.

The scientific MaaS literature review is composed only of English-written, peer-reviewed journal articles (published or in press) from the Scopus Database that had the exact words “Mobility as a Service” in their title until December 5th, 2019, obtaining 31 records. Additional literature was obtained by applying backward snowballing, which

consisted of searching for references: one paper led to another, and so on. When duplicates were discarded, we had kept 40 research articles. The search for grey literature was exclusively through online resources, selecting documents from newspapers, different websites, blogs, media companies, reports and online magazines that mentioned anything related to shared mobility and MaaS in Madrid, obtaining 43 documents. The news that mentioned the exact keywords “micromovilidad” (“micromobility” in Spanish), “movilidad compartida” (“shared mobility”) and “movilidad como servicio” (“mobility as a service”) were searched in the most important Spanish newspaper, called “El País”. Another useful source of information, especially when comparing services worldwide, was the mobility aggregator called Urbi app, that records shared mobility services worldwide. The inventory was also complemented, specifically for the case of scooter sharing, with official information from the City of Madrid (Town Hall), found on their open-data webpage (“Catálogo de datos”), where they listed the scooter-sharing companies allowed to operate and the limited fleet that was recently approved (February 2019) (Comunidad de Madrid, 2019a).

Primary information was collected through direct author observation of services around the city in two field-work activities: one carried out in November 24, 2019 (9:00 to 14:00 h), and the other on January 20, 2020 (9:00 to 14:00). The authors made annotations of service names and vehicle characteristics and completed an Excel sheet (which then became our main database). With the listed services, the authors downloaded each application and conducted an online search for each service’s website to complete information regarding price, schedules, coverages areas, etc. The database was then filled with all the information systematically extracted from the observations in field work and the services’ websites and applications up until January 2020. In the case of scooter-sharing vehicles, the fleet considered was the number of vehicles approved by the City of Madrid. To clarify, we mean that the companies may be operating more or fewer vehicles today, but we considered vehicles licensed by the City.

4. Results: madrid, a living lab for shared mobility

4.1. Atomisation at its boiling point: operators and fleets

Madrid has been flooded with new shared mobility services since 2010, when the earliest car-sharing companies began operations (Respiro and Bluemove). As described in Fig. 3, shared mobility in Madrid is only a decade old, with car sharing and bike sharing being the first services introduced (2010–2016). More recently, moto-sharing (2018) and scooter-sharing services (2019) are bursting on the scene.

Madrid’s diverse shared mobility offer is recognisable worldwide.

According to the mobility aggregator URBI, operating globally in more than 47 cities, Madrid concentrates the largest number of transport operators (public and private), with 23 companies, followed by Milan and Paris, with 19 operators (see Fig. 4). Madrid offers more services than the average North American/Canadian/European city. It is important to highlight that some of the services operating in every city may not be aggregated in the Urbi app, but it does offer a worldwide scenario for a quick comparison. In fact, when further analysed, the Urbi app’s figures for Madrid fall short, since it is concentrating at least 35 shared mobility services managed by 29 operators as listed in Table 1.

Madrid concentrates approximately 30 thousand shared vehicles. It is important to highlight that this number is merely a proxy of the reality, since this result was obtained from considering, in the case of car sharing, moto sharing and bike sharing, the fleet reported by different sources of information (news, reports, etc.). In the case of scooter sharing, particularly, we considered the fleet permitted by the City, which means that the scooter’s operators may, in fact, manage fewer/more vehicles. However, this figure is relatively close to the approximation made by Granda and Sobrino (2019), estimating 21,600 vehicles.

The largest fleet is offered in car-sharing services with 10,471 units, followed by scooter sharing with 9,859 units. Leading companies in terms of fleet are: Uber, Cabify and ShareNow (in the case of car sharing), E-cooltra and Coup (in the case of moto sharing), Bicimad (for bike sharing) and Circ, Bird and Bolt (for scooter sharing). The approximate fleet (24,495 vehicles) only accounts for 1.5% of the total automobile fleet of the Municipality of Madrid (1,919,036 as of 2017) (Comunidad de Madrid, 2019b). However, this is a large fleet of vehicles introduced into the city in such a short period of time, and the general perception of users seems to be that the urban landscape, “for good or bad, has completely changed” (Martínez, 2018).

Almost half of operators (14 firms) are scooter-sharing services (48.28%), this being the most developed and youngest market (Monzón et al., 2019) (see Fig. 5). Moto sharing services show great dynamism, as well, with 13.79% of the share of companies operating since 2017.

Although scooter and moto-sharing services were the last to be introduced, they show great dynamism and a process of atomisation, with a rapidly-growing ecosystem of operators. The scooter sharing sector is the most dynamic, with many start-ups being rapidly created, and in some cases, purchased and merged with other parties (see Fig. 6). The most recent cases are the company Circ, which acquired Flash and Koko (El Español, 2019a), Muving, which partnered with Ioscoot (which had already purchased Motit) (De Aragón, 2019), Coup, which ceased operations permanently, reporting stiff competition (most likely being

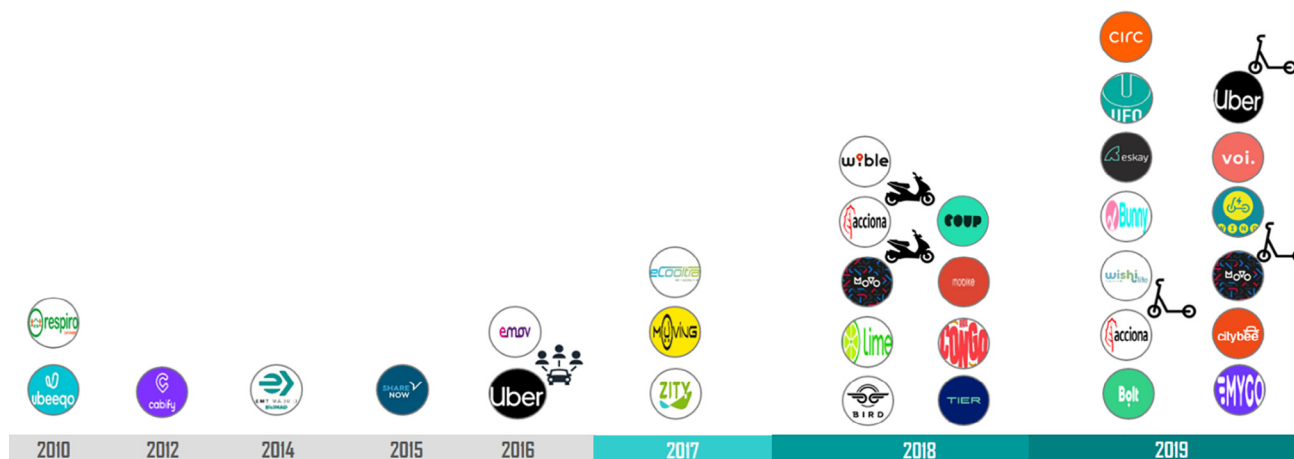


Fig. 3. Timeline of shared mobility services in Madrid. Source: the authors. The figure indicates the year in which the service began operations in Madrid particularly (this year may be different for other cities). The companies that are repeated in more than one year began operating other sharing modes (shown with icons).

MADRID's place in the world (URBI app)

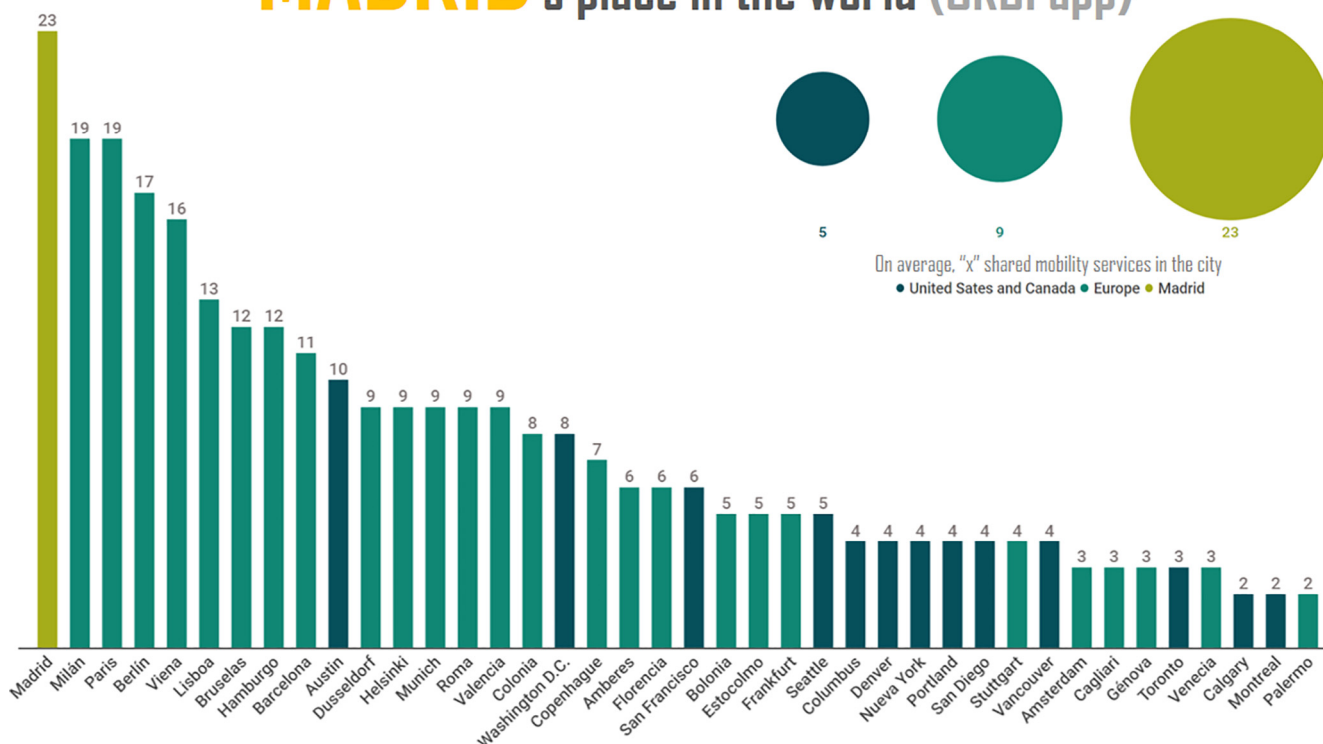


Fig. 4. Urbi app's data related to shared mobility services worldwide. Source: the authors, based on the Urbi app's public data.

purchased by a larger company) (De Vega, 2020; Javier, 2019), Voi, temporarily closing operations for the low-profit winter season and while new regulations appear, and My Go, being purchased by a Californian company called Wheels (Baldi, 2020).

When analysing the firms behind each operator, the majority of companies are backed by consolidated/large firms (24 companies), while only 11 are start-ups. However, some of the consolidated firms were once start-ups, and in some other cases, the operators were start-ups until they sold or merged with a consolidated firm. Consolidated companies are usually in the automotive industry (e.g., Daimler, Peugeot, Seat, etc.), or related to technological solutions (e.g., Acciona, Neutron Holdings, Uber, etc.).

The majority of services (apart from Bicimad, Respiro and Ubeeqo) offer free-floating mobility, allowing users to park the vehicles anywhere, which is convenient for users, but has also raised controversy, since the vehicles are occupying sidewalks (removing space for pedestrian circulation) (Martínez, 2018). The new City Ordinance (Comunidad de Madrid, 2019a) is an effort to regulate the sector by exhorting users to circulate on the road at no more than 30 km/hr and to provide public space for adequate parking (Medina, 2018; Servimedia, 2019). Safety issues are the most important factor for operators and citizens, and have also been addressed in the new Ordinance, especially after a casualty caused by an accident involving a scooter in Barcelona around November 2018 (García, 2018). Some of the operators began taking actions on the safety issue, such as Coup (moto sharing), which offered a free course for beginners with motorcycles (Domínguez, 2019a), as well as MyGo (now Wheels) (scooter sharing), which offers a free insurance for users to cover all accidents (Portalic, 2018).

4.2. Implemented fares and fees

When analysing their fees, the shared-mobility ecosystem is quite

heterogeneous (see Fig. 7). It is important to highlight that, for the fees analysis, we have chosen only services that offered price information per minute on their websites or applications, and we converted this data to 15-minute intervals for purposes of better comparison. Bike sharing is the most economically convenient mode, especially Bicimad, as could be expected, since this is Madrid's public bike-share system. Car rental companies like Respiro and Ubeeqo are also relatively low in cost per minute, which could also be expected, as they are usually used for inter-city trips covering greater distances in comparison with urban services for short trips. However, even though the price per minute seems competitive, these car rental companies have a higher cost, as they charge users for gas expenses.

The most high-priced services include: Mobike for bike sharing, E-cooltra for moto sharing, Wible for car sharing and Acciona for scooter sharing. When comparing them all versus all, the most expensive services are Wible (4.2 euros/15 min), E-cooltra and Zity (3.9 euros/15 min) and Free2Move, Coup and Muving (3.75 euros/15 min). Another important observation is that almost all scooter-sharing companies have the same price of 2.25 euros/15 min and 1 euro for unclogging the vehicle. The most price-convenient services for scooters are Ride Conga, Movo and Jump, with prices below 2 euros. On the other hand, the highest priced scooter services are Bird and Acciona, at more than 3 euros. In the case of car sharing, the most price-convenient services (apart from car rental companies) are ShareNow (Car2Go before) and Free2Move (Emov before), but they charge an entry fee (registration) of 9 euros, while the rest of services have free registration. The mean price is 2.42 € per 15 min. In general, bike and scooter sharing charge below the mean price (with bicycles being cheaper), while car and moto sharing charge relatively similar prices above the mean price.

This price hierarchy in Madrid could be seen as positive, as the modes that occupy less space are cheaper (bicycles and scooters), incentivising their usage. In considering prices in relation to the fleet of

Table 1
 Madrid's shared mobility inventory (Database). Source: the authors, based on different sources shown below.

Sharing mode	Operator	Service Name	Type *	Mergers	Source	Fleet	Source	Companies behind	Source	Schedule	Price (€/minute)	Entry fee	Operating in Madrid since
Car haring	1	Share Now	1	DriveNow + Car2Go	a	850	1	BMW Group + Daimler AG	I	24/7	0.19	9	2015
	2	Free2Move	1	Emov	b	605	1	PSA Peugeot-Citroën	b	24/7	0.25	9	2016
	3	Respiro	2			218	2	Seat	II	24/7	0.033	Free	2010
	4	Ubeeqo	2	Bluemove	c	344	2	Europcar Mobility Group	c	24/7	0.033	Free	2010
	5 and 6	Uber + Cabify	1			7.269	3	Uber + Cabify		24/7	No info	Free	2012 y 2016
	7	Wible	1			500	1	Repsol + Kia	III	24/7	0.28	Free	2018
	8	Wishilife	1			35	IV	EMC emobility Concept	IV	24/7	No info	Free	2019
	9	Zity	1			650	1	Ferrovial + Renault	V	24/7	0.26	Free	2017
	Subtotal	9	9				10,471						
Moto sharing	10	Acciona	1			1,000	1	Acciona S.A.		24/7	0.19	Free	2018
	11	Coup	1			1,350	1	Bosch	VI	24/7	0.25	Free	2018
	12	E-cooltra	1			1,800	1	Cooltra Group	VII	24/7	0.26	Free	2017
	13	Muving	1	Ioscot (Motit4U) + Muving	d	1,000	1	start up		6:00–3:00	0.25	Free	2017
	6	Movo	1	Movo + SJV Consulting	1	515	1	Cabify	VIII	24/7	0.2	Free	2018
Subtotal	4	5				5,665							
Bike sharing	14	Bicimad	2			2,500	1	Empresa Municipal de Transportes (EMT)		24/7	0.017	15	2014
	15	Mobike	1			1,000	1	Mobike		24/7	0.05	Free	2018
Subtotal	2	2				3,500							
Scooter sharing	10	Acciona	1			179	4	Acciona S.A.		8:00–23:00	0.23	Free	2019
	16	Alma	1			140	4	start up		Not yet operating			
	17	Buny (Ari Sharing)	1			420	4	start up			0.15	1	2019
	18	Bird	1	Bird + Sccot	g	1,106	4	Bird	XII	7:00–21:00	0.2	1	2018
	19	Citybee	1			246	4	Modus Group	XII	7:00–21:00	0.15	1	2019
	20	Eskay	1			64	4	start up		No info	0.15	1	2019
	21	Circ	1	Flash + Koko	e	2,296	4	start up		7:00–21:00	0.15	Free	2019
	5	Jump	1			566	4	Uber	IX	No info	0.12	1	2019
	22	Lime	1			641	4	Neutron Holdings	X	7:00–21:00	0.15	1	2018
	15	Mobike	1			170	4	Mobike		Not yet operating			
	13	Muving	1	Ioscot (Motit4U) + Muving	d	36	4	start up		Not yet operating			
	6	Movo	1	Movo + SJV Consulting	1	1,440	4	Cabify	VIII	24/7	0.11	Free	2019
	23	MyGo	1			90	4	start up		7:00–21:00	0.15	1	2019
	24	Ride Conga	1			403	4	start up		No info	0.11	Free	2018
	25	Bolt	1	Bolt + Taxify	f	750	4	start up		No info	0.15	1	2019
26	Tier	1			484	4	Tier	XII	7:00–22:00	0.15	1	2018	
27	Ufo	1			530	4	Seat	XI	No info	0.15	1	2019	
28	Voi	1			162	4	start up		No info	0.15	1	2019	
29	Wind	1			136	4	start up		6:00–22:00	0.15	1	2019	
Subtotal	14	19				9,859							
Total	29	35				29,495		11 start-ups/24 consolidated					

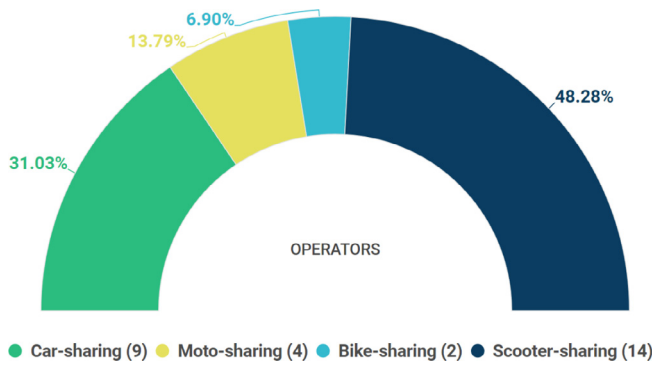


Fig. 5. Share of companies according to the mode of transport that they operate. Source: the authors.

the companies, we found that in general, as the fleet increases, so do the prices (see Fig. 8). This outcome is different only in the case of Bicimad, which has the lowest rate and the largest fleet of all. The same occurs with ShareNow, Circ and Movo, which have a competitive fleet of scooters and a relatively low price.

In the case of bike sharing, Mobike offers less than half of Bicimad’s fleet and doubles its price, making Bicimad the most price/fleet convenient option. In return, Mobike users may leave and pick up their bikes wherever they want, while with Bicimad, they are obligated to take/return them at bike stations. In the case of moto sharing, E-cooltra offers the highest price, but also a competitive amount of vehicles around the city, which guarantees users that they will always be near a motorcycle. Moving has a lower fleet than Coup and offers a similar price, which makes Coup more convenient in terms of price and fleet. And lastly, Movo and Acciona are the moto-sharing companies with the fewest motorcycles (as well as lower prices), but Acciona offers a lower price and doubles Movo’s fleet, and is more competitive.

When analysing car sharing, ShareNow (Car2Go before) undoubtedly has the largest fleet and the most competitive price, while

the rest of companies offer fewer vehicles at higher prices, especially Wible. And finally, with scooter sharing, Circ and Movo are the most competitive in terms of fleet (2,296 and 1,440 vehicles, respectively) and price (2.25 and 1.65 euros per 15 min, in that order). Companies such as Eskay, MyGo, Voi, Wind and Acciona have fewer vehicles and the charge prices similar to other companies with a larger fleet, especially Acciona, which charges 3.46 euros per 15 min of ride. However, with Acciona, the scooter is unblocked for free, while the rest of companies charge one euro, which increases the price. Free scooter unblocking is also present with Circ, Movo and RideConga, making the first two the most convenient options for users as they hold the largest fleet, the lowest prices and do not charge for unclogging the scooter.

Each service has a coverage-zone map integrated into their apps, so users can easily know where they can pick up/leave the vehicle. Mostly all shared mobility services are concentrated in the central area of Madrid (called “Almendra Central”), and are scarce around the M-30 highway border (1st ring), and non-existent in the peripheral areas of Madrid’s Metropolitan Region (see Fig. 9). This is quite inconvenient for those who live in the outer peripheral zones, because they cannot use shared mobility services to solve their last-mile problem.

Operational schedules vary according to the specific electric mode and their autonomy (for recharging batteries). Regarding bike-sharing, Bicimad and Mobike bicycles allow 70 km of autonomy. In the case of the public bike-share system, they are charged at the different bike stations around the city, while in the case of Mobike, they are either taken by the user to charging stations (with price incentives) when needed or picked up by the company. All bikes are available 24 h, seven days a week (24/7).

In the case of car sharing, they are all available 24/7, because they have greater autonomy that varies from 150 km (e.g., Emov, Car2go) to 400 km (e.g., Zity). In the case of moto sharing, autonomy varies from 40 to 55 km, and in the case of scooter sharing, depending on the companies, autonomy is around 20 to 30 km. In the case of moto sharing, they usually are available 24/7, because the technical recharging is done on the street (changing the battery). However, in the case of scooter sharing, the majority of companies deploy the vehicles

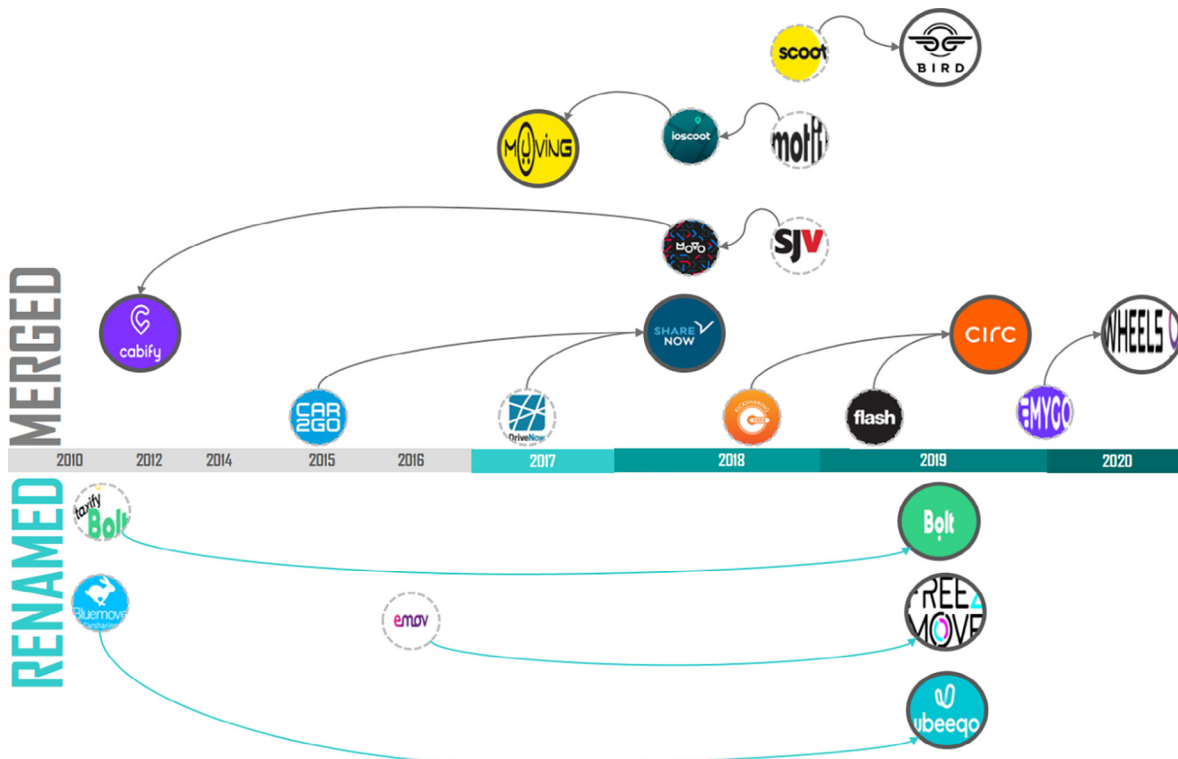


Fig. 6. Dynamism in the sharing sector. Source: The authors, based on news referenced in Table 1, “Mergers” column.

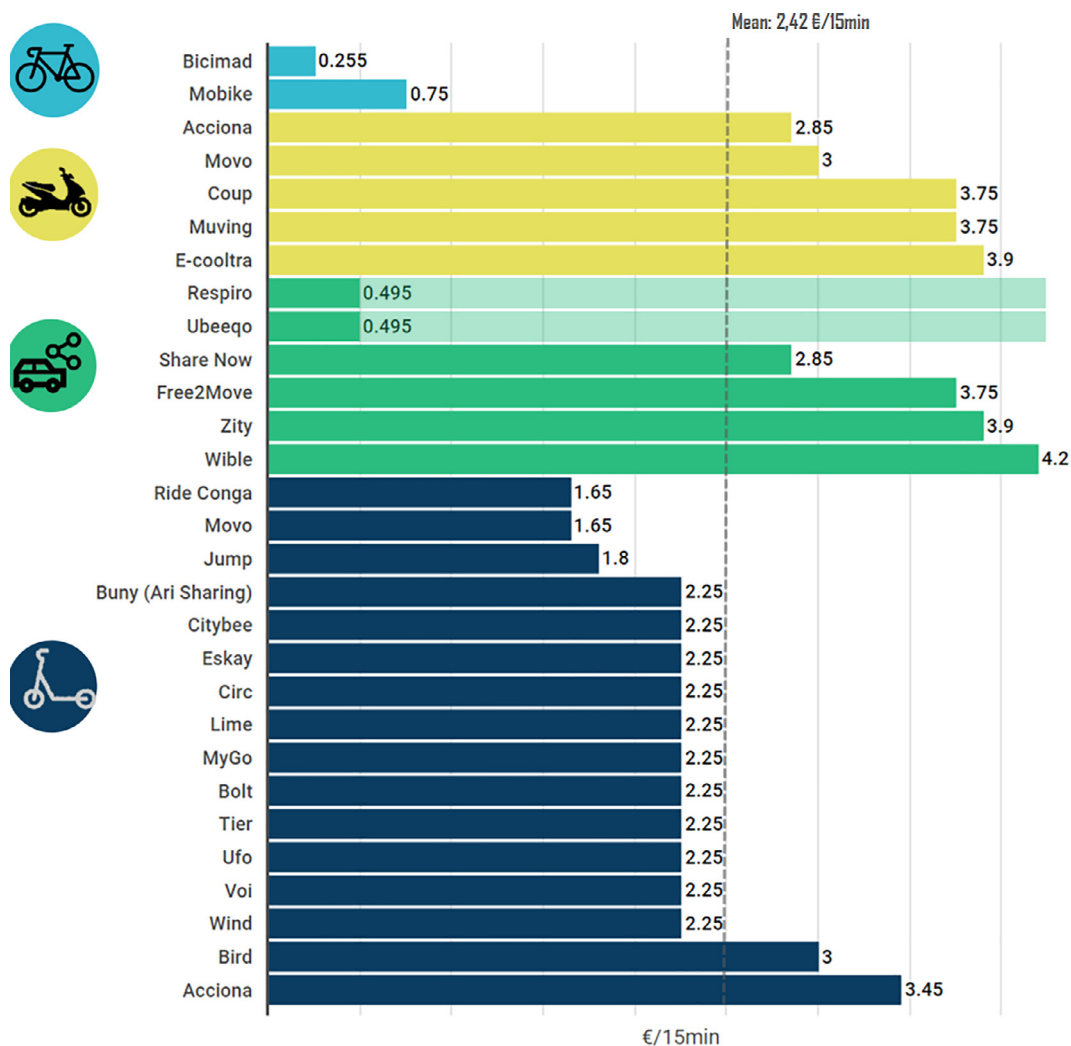


Fig. 7. Fees for shared mobility modes in Madrid. Source: the authors, based on information from Table 1, column “Price”. Companies that did not offer fee information or that did not offer fees in terms of price per minute were excluded.

in the morning and collect them around midnight to recharge batteries. This creates additional logistical and distribution costs for operators and also creates an inconvenience for users who may want to use scooters after midnight, when the subway is not available.

In an effort to increase the coverage area of these services, including peripheral areas, to promote last-mile trips and intermodality, the City of Madrid approved scooter-sharing licences and established different distribution zones for the fleet of vehicles, as seen in Fig. 10. Each company operating scooters is exhorted to deploy their vehicles in a particular zone every morning, and then users may take them anywhere they want. The map shows that more vehicles should be deployed where there is a greater population, such as in peripheral northern areas (e.g., Valdefuentes neighbourhood in the Hortaleza District) as well as the western neighbourhoods of Madrid (e.g., Aravaca neighbourhood in the Moncloa District).

4.3. A brief glance at the growing demand for shared mobility services

Shared mobility services seem to be slowly but surely attracting more users every day. In the case of bike-sharing, Bicimad has around 65,000 active subscribed users, with more than 3 million trips according to their open data (Ayuntamiento de Madrid, 2019a). As highlighted by (Romanillos, 2018), the cycling modal share in recent years reveals this intense growth, going from 0.22% in 2008 to 1.20% in 2015.

In the case of car-sharing services, ShareNow has reported having 237,000 users in Spain (Ruiz-hidalgo, 2019), compared to Free2Move, which has 200,000 users (Soria, 2019), Zity with 157,000 and Wible with 100,000 (Ruiz-hidalgo, 2019). In the case of moto sharing, figures found in news and grey literature position E-cooltra as the most populated service, with 750,000 users in Spain (López-Redondo, 2019), while Muving has 350,000 users (De las Heras, 2019). Although the majority of services do not offer information on the number of subscribers, with the ones that do, can observe that the increased number of users in Spain, and certainly in its capital, Madrid, is a positive aspect regarding shared-mobility demand.

Velázquez Romera (2019) evaluated the factors that impact the adoption of new mobility solutions in Madrid (bike-sharing system, car-sharing system and a multimodal app). It showed, with bike-sharing, that user satisfaction with the bike-sharing system’s operation and vehicles are the most important factor. Being non-technophile had a negative effect in bike-sharing usage, supporting the relevance of considering this population as stated by (Pangbourne et al., 2019). In the case of car sharing, privacy concerns had the most negative impact on the adoption of the service and, lastly, in the case of the multimodal app, technophilia and previous use of transport apps strongly explained the adoption of the app (Velázquez Romera, 2019). The usual socio-economic characteristics of the target population for shared mobility services are young people, well-educated (digitally literate) and early adopters, but in order to expand shared mobility and increase its

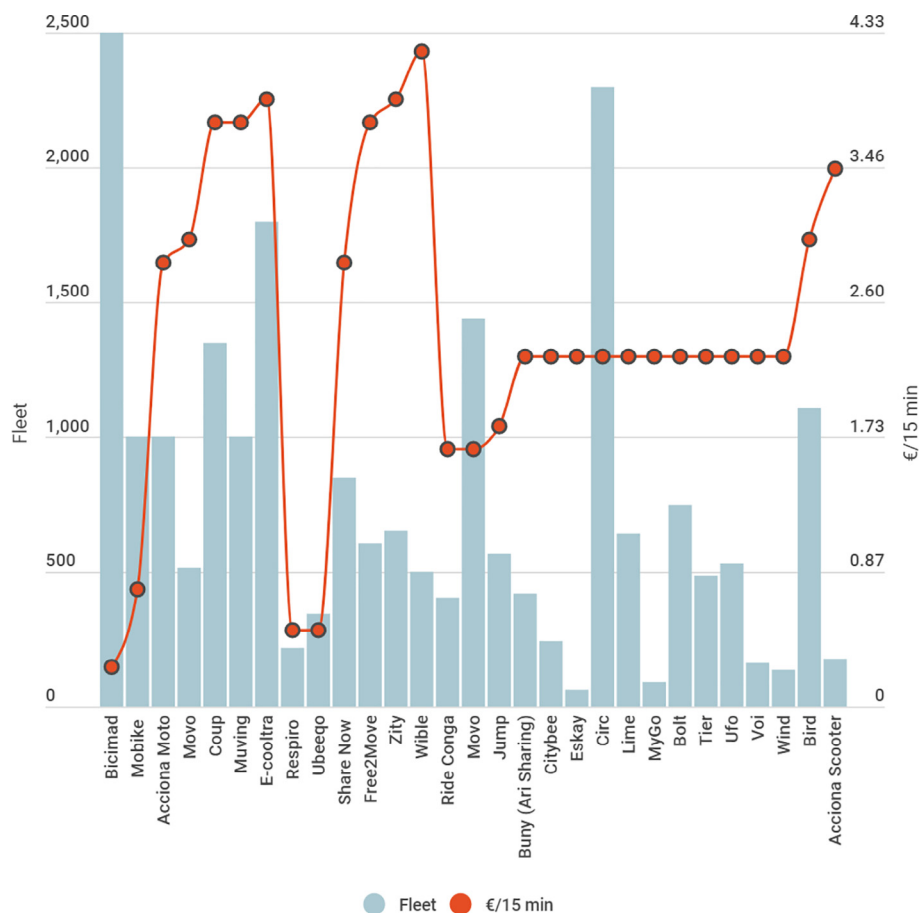


Fig. 8. Fleet and price comparison of Shared Mobility in MadridSource: the authors, based on information from Table 1.

impact, operators must consider different factors that influence their adoption.

5. Discussion and conclusions

5.1. Development of mobility as service (MaaS) in Madrid

Our diagnosis of shared mobility services indicates that Madrid may have the two conditions necessary to implement MaaS, as stated by Li and Voegelé (2017). Consequently, new MaaS pilots are emerging in the city.

In the case of the public sector, Madrid’s authorities have been collaborating with research institutes and technological companies to integrate their payment and ticketing ICT infrastructure so that users may pay all their different mobility services with their smartphones (Consortio Regional de Transportes de la Comunidad de Madrid, 2019), which is basic for users to be able to pay through the app for mobility services. Public authorities have also announced that they will begin using mobile record data to analyse mobility patterns in the city, generating a great amount of information to carry out MaaS modelling studies.

Moreover, there are different MaaS initiatives coming from the public and private sectors. Firstly, the Municipal Transport Enterprise (EMT), which operates Madrid’s city bus service, cableway and Bicimad (bike-share system), is developing a MaaS application called “MaaS Madrid” to integrate each mode available in the city. They have recently announced that a beta version of the app is already available as an information aggregator, where users find real-time information from different services (scooter sharing, bike sharing, moto sharing, car sharing, bus, metro, train, etc.). They have reported that they are now working on app personalisation and have already gained 3,000

subscribers, recording their daily mobility tracks.

Secondly, Renfe, the primary rail operator in Spain, is also developing its MaaS application, called “Renfe as a Service (ReeS)”. They will launch the beta version of the app in November 2019 and are now willing to become a mobility service operator. They have announced their strategies to collaborate with different stakeholders, operators, partners, etc. The pilot version is being tested by 500 people, selected to record their daily tracks and improve the beta version.

In the private sector, three main initiatives have arisen. The first one is Wondo, a service aggregator with real-time information regarding all mobility operators in the city (public transport and shared mobility). The app established partnerships with E-cooltra (moto sharing) and Emov (car sharing) to pay for rides with the “Wondo tickets” that the users previously purchased. But in its recent stage, the application simply redirected users to Ecooltra and Emov applications. In November 2019, the Wondo team announced they were partnering with Moovit (which already had more subscribers) and that their platform was now going to be the MaaS provider. Moovit aggregates real-time information regarding different mobility services and also allows users to buy shared mobility rides for some of the moto-sharing and scooter-sharing companies through Wondo tickets.

The third most important private initiative is Chipi. This application integrates public transport and the majority of shared mobility services available in the city. One of the most interesting functionalities of the app is that it compares distances, travel time, prices and calories for each modal chain (it is one of the few multimodal journey planners). However, like the other initiatives, this application is still merely an information aggregator, since it redirects users to each operator application when paying for their rides.

Although there are different MaaS initiatives coming from the public and private sector, they are mainly in early stages or pilot

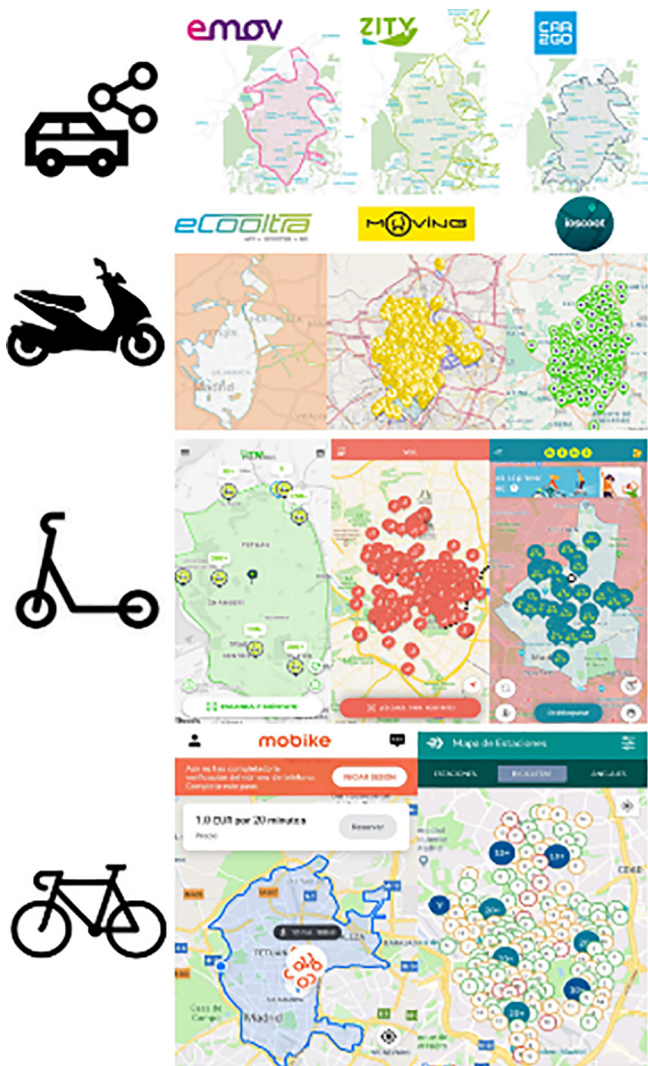


Fig. 9. Covering zones of shared mobility in Madrid. Source: the authors, based on the coverage offered in the different apps.

versions, which are still much removed from more advanced MaaS applications, such as Whim in Finland or Ubigo in Sweden (Kamargianni et al., 2016). Additionally, there is scant collaboration between the different initiatives to create a single MaaS app for Madrid, which could, in fact, lead to having even more available applications, and basically contradicting the MaaS concept. Thus, collaboration and governance frameworks are needed in the city to outline the transition path for MaaS to become the new socio-technological regime.

5.2. Madrid’s path for transitioning to a MaaS regime: upcoming steps

As our results show, Madrid has a cluster of conditions that make the city a potential candidate for MaaS developments. The first one is having a dense, diverse and young population served with a good public transport system, as is common in many European capitals. However, the most important condition currently, and the one explored in this paper, is that Madrid is becoming a living lab for shared mobility with its diverse shared mobility offer.

With 29 operators identified and an approximate fleet of 30 thousand vehicles, mobility patterns are definitely changing. On the landscape level (based on the MLP perspective), two main factors have an influence: first, new technological advances, such as 5G connectivity, geolocation, data processing and other innovations, are making it possible for on-demand services to find their place and offer users an

alternative to the private vehicle, especially when solving their last-mile problem. On the other, a young population, interested in sharing more than “owning” assets, is warmly embracing these new forms of mobility, especially in the context of the serious climate crisis that the planet is facing (Heikkilä, 2014; Pangbourne et al., 2019).

In the case of Madrid, we have seen that the shared mobility offer is quite recent (only a decade old), but it has evolved at a quick pace. Authorities have openly welcomed these new forms of mobility, approving an Ordinance (Comunidad de Madrid, 2019a) to regulate them and limiting the scooter fleet, for now, to around 10,000 vehicles. The City is studying parking regulations and strategies to increase intermodality, with a more flexible attitude than other Spanish cities (Granda and Sobrino, 2019). According to interviewed operators, some of the factors favouring the spread of sharing are relatively good weather, as well as the City’s openness to new stakeholders and services oriented toward reducing automobile dependency (Barciela, 2019; Granda and Sobrino, 2019).

Currently in Madrid, these services are quickly evolving, with many start-ups being created and merging with others. The atomisation of services, and the dynamism of merging strategies, is at boiling point; hence, this current panorama may still vary considerably until reaching a stable position. The fact that many of the operators are consolidated companies (and not start-ups) that are investing in the mobility arena could be considered as a positive aspect, since this could lead to an increased shared mobility offer in Madrid.

We now have knowledge that bike-sharing and scooter-sharing services are the most price-convenient, which could be also seen as positive, since the modes that occupy less space are more price-accessible. The price convenience may be the result of relatively lower implementation costs when compared to car and moto-sharing services, which have higher maintenance and operational costs. When analysing both prices and fleets, we observe that for some services, the rule “more fleet, lower price” applies, but for some others, it does not. The most price/fleet-convenient services found were: for bike sharing, Bicimad, for moto sharing, E-cooltra (if users prefer more fleet) and Acciona (if users prefer lower prices). In the case of car sharing, the most competitive service is ShareNow and lastly, for scooter sharing, Circ (if users prefer more fleet) and Movo (if users prefer lower prices).

We have also analysed the conflicts and limitations that are still challenging these services, such as safety issues due to the scarce road infrastructure provided for circulation, or the lack of public space for parking, and consequently, unsuitable occupation of sidewalks that interrupts pedestrian flows. One of the main challenges, in which the City has already taken some action, is the effort to decentralise services from the city centre in order to efficiently promote intermodality for residents that live in peripheral areas. If the current panorama continues, decreased potential for substituting car trips coming from peripheral neighbourhoods could be expected.

As far as positive aspects are concerned, we could highlight all sharing services boast electromobility, which helps to decrease noise and air pollution. Most companies have free-floating services, offering users door-to-door mobility, which helps them be more attractive and a real alternative to the car. There are only three station-based services (Respiro, Ubeeqo and Bicimad), since free-floating services appear more flexible and attractive to users, although some regulations must be made to avoid new accidents.

In general, if shared mobility services continue to grow and solve last-mile problems, MaaS could become the new transport paradigm in Madrid. The rapid development of mobility applications will continue to increase the need to integrate them all into one single location, allowing operators to create MaaS initiatives, and thus prompting MaaS. Therefore, this diagnosis of the current situation in Madrid could help authorities, mobility operators and other stakeholders to become aware of the opportunity for the city: Madrid is transitioning into a MaaS regime with the rapid development of shared mobility services at niche level. As new shared mobility services continue to appear, the MaaS

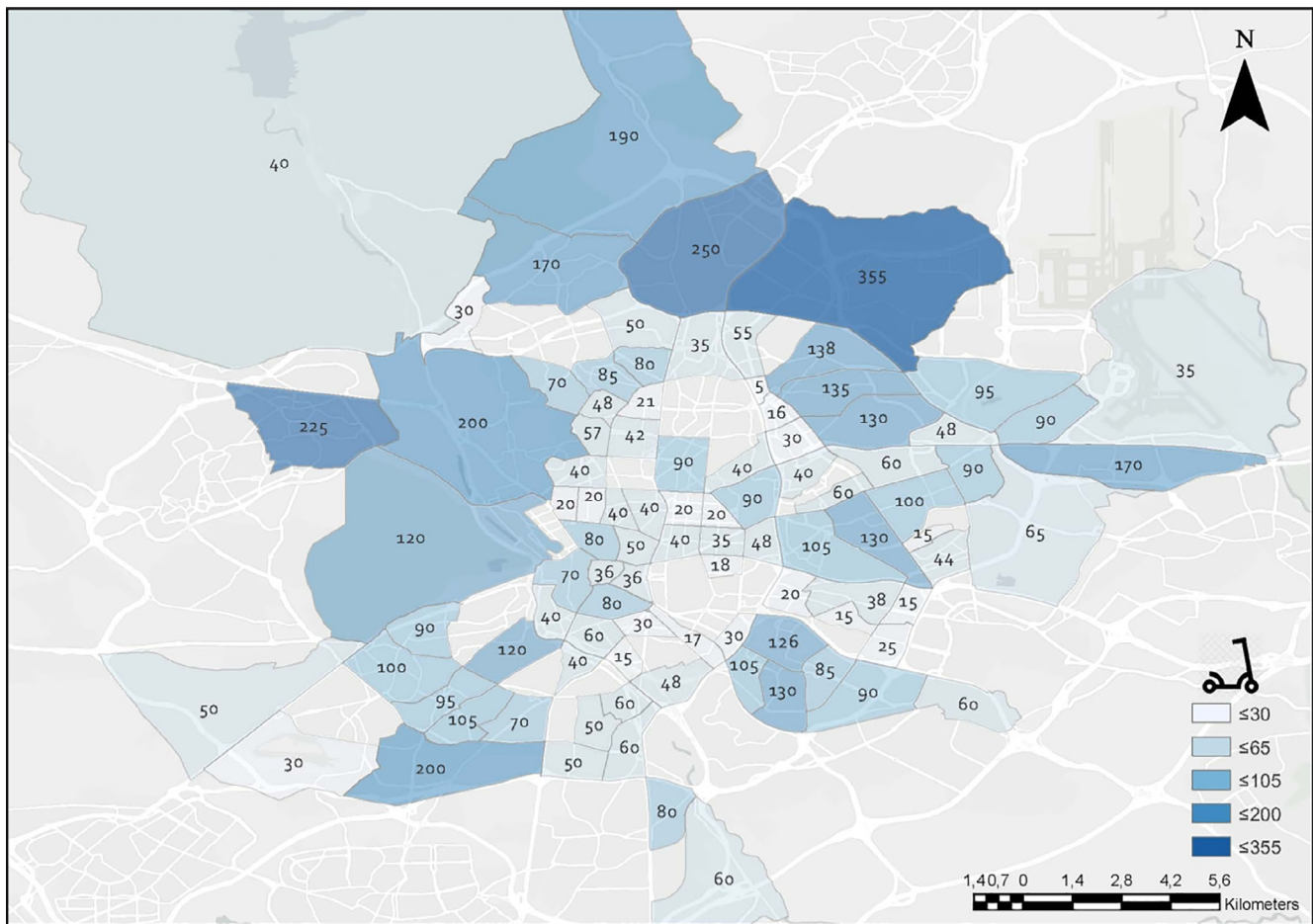


Fig. 10. Distribution of scooters around Madrid approved by the City. Source: The authors, based on (Comunidad de Madrid, 2019a).

mobility ecosystem will also grow, increasing MaaS’ potential to be successfully implemented.

The upcoming steps or general recommendations for implementing MaaS include the public–private collaboration needed for MaaS (Ho et al., 2018), the data-format standardisation and interoperability required to integrate different operators into one single application, the evaluation of MaaS’ impacts (social, economic and environmental), as stated by (Fioreze et al., 2019; Pangbourne et al., 2019), and the regulation/governance of this new emerging mobility paradigm (Surakka et al., 2018). Governance and collaboration must be the main priority in developing MaaS in Madrid, as our results show little or no cooperation between different stakeholders to create a single MaaS app. For now, the three MaaS initiatives that are taking place in Madrid are still in an early stage and are not allowing users to use the three main functionalities of a MaaS service, which are to *plan, pay and access* mobility services from one single application (Kamargianni and Goulding, 2018).

5.3. Limitations and future research directions

Limitations on this study include only considering the Urbi app for comparison analysis of the European situation regarding shared mobility, which could be short in its different countries’ figures, as happened with Spain. Our focus, however, was to diagnose Madrid’s situation based on a general, initial European panorama. Another limitation is that we conducted the diagnosis of shared mobility services in Madrid until December 5, 2019, which may be outdated by now.

Furthermore, one of the main benefits of developing case studies is drawing recommendations for future research based on lessons learned

from the methodology used. Our methodology was focused on observation and digital scientific/grey literature searches, but future research directions may be oriented toward collecting primary data from shared mobility operators through surveys or structured/semi-structured interviews, updating the rapidly-changing database. This could help to update not only quantitative aspects (number of operators, fleet and prices offered), but also qualitative aspects, by closely analysing the causes of different interactions (renamed/merged/ceased) that are taking place. Directly interviewing shared mobility operators could draw lessons regarding healthy business models for MaaS and its current feasibility from the operators’ points of view, contributing to the development of MaaS governance frameworks.

A second research direction could be to analyse mobility patterns of shared mobility services in Madrid and analyse their impact on peripheral areas. Studying how the different modes interact with each other (intermodality for first/last mile) and modelling a MaaS service will help to explore MaaS demand. And lastly, a third recommended research line is to conduct more case studies that are urgently needed in Spain and other countries, in order to create a solid literature base that could contribute to further clarify if shared mobility services are acting as enablers of MaaS. We recommend our approach in different cities in order to establish valuable comparisons, as no other study was found regarding this subject.

Author contribution

Arias-Molinares, Daniela: review, methodology and visualisations. García-Palomares, Juan Carlos: conceptualization, revision and validation.

CRediT authorship contribution statement

Daniela Arias-Molinares: Methodology, Visualization. **Juan Carlos García-Palomares:** Conceptualization, Validation.

Acknowledgments

The authors gratefully acknowledge funding from El Ministerio de Ciencia, Innovación y Universidades (MCIU) through Agencia Estatal de Investigación (AEI) and cofounded by the European Regional Development Fund (FEDER, UE) through the Project “RTI2018-098402-B-I00”.

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