



ANALYSIS OF MOBILITY PATTERNS AND INTENDED USE OF SHARED MOBILITY SERVICES IN THE BARCELONA REGION

Mireia Gilibert

SEAT, S.A., Autovía A-2, Km. 585 08760 Martorell, Spain
Departament d'Organització d'Empreses (DOE), Universitat Politècnica de Catalunya ·
BarcelonaTech (UPC), Av. Diagonal, 647, 08028 Barcelona, Spain

Imma Ribas

Silvia Rodríguez-Donaire

Departament d'Organització d'Empreses (DOE), Universitat Politècnica de Catalunya ·
BarcelonaTech (UPC), Av. Diagonal, 647, 08028 Barcelona, Spain

ABSTRACT

Social and economic trends have strongly changed in the last years due to the economic crisis and the evolution of technology. These factors have influenced a sharing revolution, also in the mobility sector motivated for the increasing urbanisation and environmental consciousness. The paper focuses on the intended use of shared mobility services by citizens of the metropolitan Barcelona region, relying on a quantitative analysis of their mobility patterns, behaviours, needs and expectations. Six hundred surveys with commuting travellers were conducted in order to identify the differences among customers regarding different factors, such as their age, daily trips or personal incomes. Results show clear different patterns depending on whether commuting trips are within or out of the city and a greater intended use of ridesharing, carsharing and ride-hailing services of the youngest population. Besides, data indicates that travellers do not have preferences for a single mean of transport but for the service that best meets their needs in each occasion.

1. INTRODUCTION

Urban mobility is a current trending topic. On one hand, cities are beginning to face the rising problem of urbanisation. According to the United Nations, Department of Economic and Social Affairs, & Population Division (2014), more than half of the world's population lives in urban areas nowadays, proportion which could increase to 66% by 2050. This increase of urbanisation is causing, on the other hand, a growth of urban traffic and therefore, a rise of environmental and health problems. Mueller et al. (2016) affirmed that there are nearly 3,000 premature deaths per year in Barcelona (city with a population of 1,604,555 inhabitants (Barcelona City Council, 2016a)), most of them because of the pollution of the city. Besides, the European Environment Agency (2016) pointed out that air-pollution, particularly in urban areas,



caused 29,980 early deaths per year in Spain and 520,000 in the EU-28. Although driving restrictions are being more common, it is believed that the solution to urban traffic and its associated problems will be brought by new mobility alternatives, meaning integrated shared electric and autonomous mobility services.

Furthermore, the sharing economy or collaborative economy (a similar concept also used to encompass these activities) is very present nowadays in all its different forms. However, the origin is quite old, since for instance, bikesharing dates from 1960s, time banking from 1980s and the market places eBay and Craigslist from 1995 (Cohen & Kietzmann, 2014; Schor, 2014). The explosive growth of sharing economy activities, which every passing day have more followers, is linked to the recent economic crisis. The increasing rate of unemployment, the growth of precarious jobs and the loss of consumer purchasing power encouraged the adoption of this lifestyle economy. Although sharing as alternative to ownership is not a new concept, Internet and mobile technology (facilitators of Peer-to-Peer (P2P) platforms) have turned sharing economy into a big business, the rapid growth and expansion of companies such as Uber in the urban transportation sector or Airbnb in the accommodation sector are disrupting not only the traditional service industry but also long-established firms (Cannon & Summers, 2014).

Public transport does not cover, anywhere, the totality of the travellers' needs and, in big cities, neither does the private transport nor the combination of both. At present, automotive manufacturers and other mobility service providers are trying to cover this gap for the new on-demand, shared and sustainable transport services. Coming from the premise that it starts to be a big number of emerging services competing in this field, some of them already very extended such as the "ride-hailings" Uber and Lyft or the "carsharings" car2go and Zipcar, probably soon there will be a lot of competition in our cities. The question is, how many of these services will succeed? For the moment, most of them are based on the sharing and circular economy, offer a similar user experience and have similar business models. Predictably, some decisive factors such as the cost, trust and convenience, should be taken into consideration in the service design. But what other aspects also have to be considered?

From literature it is found that new mobility services should merge the benefits that offers having an owned car, in terms of convenience, freedom, control, comfort and flexibility, and the positive aspects of public transportation, for



instance, affordability, efficiency and sustainability (Hietanen, 2017; Villalante, 2017; UITP, 2017; McKinsey & Company, 2015; EY Global Automotive Center, 2013; Fishman, 2012; Okuda, Hirasawa, Matsukuma, Fukumoto, & Shimura, 2012). Furthermore, all authors believe in multimodal and integrated services with the public transport offer, evolving to the Mobility-as-a-Service (MaaS) model. Some MaaS initiatives are just beginning to be implemented, such as moovel (mainly in Germany, but only offers integration with public transport in Stuttgart and Hamburg) and Whim, operating since 2016 but only in Helsinki (moovel, 2017; Whim, 2016).

2. CASE STUDY

The study developed was based in Barcelona, which is a top Smart City according to Juniper Research's ranking (Juniper Research, 2015, 2016) and where right now a lot of measures for improving the sustainability have been announced. One of them is the restriction of most polluting vehicles travelling within the city during the days with high air pollution and their total restriction from 2020 onwards (Guerrero, 2016).

Within the city, mobility due to personal reasons doubles occupational mobility (7.4 million trips per day vs 3.2 million), though the 59.7% of trips done for personal reasons are done on foot and by bike, the 11.3% by public transport and the remaining 28.9% by private vehicles; whereas the 49.4% of commuting trips are done by private cars and motorbikes, the 29.6% by public transport and the remaining 21% by non-motorised means (Barcelona Institute of Regional and Metropolitan Studies, 2016). Besides, on a working day, more than one million vehicles enters and leaves Barcelona (Barcelona City Council, 2016b).

The high use of non-motorised transport for personal mobility is very common in dense cities, since travel distances tend to be shorter (Kenworthy, 2006). According to a Eurostat study, the metropolitan Barcelona region is the 6th largest urban area in the European Union, behind London, Paris, Madrid, Ruhrgebiet and Berlin (Koceva et al., 2016). This study also indicates that this region records two of the three highest levels of population density in the EU-28. The highest ratio is located within l'Hospitalet de Llobregat, with 53,119 inhabitants/km², and the third highest ratio within Badalona, with 50,287 inhabitants/km², behind the 18th arrondissement in Paris (52,218 inhabitants/km²) (Koceva et al., 2016).

Regarding new mobility services operating in Barcelona, there is starting to be a variety of services: MyTaxi-Hailo, which is a taxi-hailing service; Cabify, which is a singular ride-hailing service operating in the city with Chauffeured Tourism Vehicle (VTC) licences; Avancar and Bluemove, both Business-to-Consumer (B2C) carsharing companies; SocialCar, Drivy and Amovens, the three of them offering P2P carsharing services; and the B2C electric motosharing services eCooltra, Yugo, Motit, Muving and Outo - Outo also offers P2P motosharing (mytaxi, 2016; Maxi Mobility, 2017; Avancar, 2017; Bluemove, 2016; SocialCar, 2017; Drivy, 2017; Amovens Soluciones, 2017; Cooltra Motosharing, 2017; YUGO Urban Mobility, 2017; Motit World, 2017; Sharing Muving, 2017; Outo, 2017).

3. METHODOLOGY

With the aim of finding out about the mobility patterns, behaviours, needs and expectations of the citizens of Barcelona and of its metropolitan Barcelona region, a quantitative study was conducted in January 2017. A total of 602 interviews were carried out on-line, using the technique of Computer-Assisted Web Interviewing (CAWI). The survey was conducted according to the norm ISO 20252 and the code of conduct CCI/ESOMAR.

The questionnaire applied was structured with closed questions. The survey asked 17 questions regarding the use, intention of use and likes and dislikes of shared mobility services, as well as the preferred options according to different types of trips, price setting, and accessibility to these services. Furthermore, 12 classification questions and 3 questions regarding the usual and preferred means of transport were also requested.

3.1 Sample

A sample profile was defined in order to ensure an equal participation rate among genders, ages and commuters and non-commuters.

Precisely, the sample profile obtained was:

- Gender: 49.83% women and 50.17% men.
- Age: 33.6% aged between 18 and 29 years old, 33.2% aged between 30 and 45 years old, and the remaining 33.2% aged between 46 and 55 years old.
- Mobility patterns: 48.34% living and working in Barcelona or its neighbouring municipalities (Badalona, Sant Adrià de Besòs, Santa Coloma de Gramenet, L'Hospitalet de Llobregat, El Prat de Llobregat

and Cornellà de Llobregat); 24.92% commuting from Barcelona or its immediate to other locations of the Barcelona Metropolitan Region (RMB), and the remaining 26.74% commuting from the RMB to Barcelona and its immediate.

- Education: 62.06% had University studies, 30.62% had High school studies, 13.49% had Elementary school studies, and the remaining 3,83% had less studies.
- Occupation: 78.84% were employed, 4.76% were unemployed, 7.41% were students which also were working, and the remaining 8.99% were students exclusively dedicated to their studies.

4. RESULTS

This section discusses the outcome of the survey. First, mobility patterns of respondents are provided and analysed by age, gender, location and employment situation. Then, the analysis continues with the use intention of the emerging mobility services studied, being aware of the limitation that most of the interviewees had never used a shared service before - bikesharing included -. However, during the survey all services valued where in every question explained in detail and with examples.

4.1 Respondents mobility patterns

More than four-fifth of respondents had a driving license (86.88%) and access to a car (82.72%) - owned or from a family member -. According to the analysis of the questions of having a driving license and access to a car by monthly incomes, it was found that the profile with more access to driving a car was directly related to the level of income and inversely proportional to the use of the public transport. Besides, responses to “Which means of transport do you use to travel in a normal working day” lead to the conclusion that the 53.49% of interviewees used more than one mode of transport every day, being the citizens with the lowest incomes the most multimodal, with the exception of the unemployed population. Accordingly, Table 1 provides an overview on the mobility patterns of respondents by employment situation. The first column shows the percentage of respondents of each category over the total answers. Next, each row gives the percentage of affirmative answers over the respondents of each category. From this table it can be seen that the segments with more use of the public transport were students and unemployed citizens. In addition, the analysis of mobility patterns and intended use of shared mobility in the metropolitan Barcelona region most

multimodal segment - students, with a rate up to 72.55% - was having by far less access to a car (54.90%). Although, it should be noted that the proportion of students and unemployed citizens from the sample is very small (ratio of students exclusively and also working: 8.47% and 6.98% respectively, ratio of unemployed respondents: 4.49%).

Employment situation	n	Have a driving license	Access or owners of a car	Daily users of public transport	Daily multimodal users	Users of shared services
Employed	74.25%	92.17%	86.80%	58.39%	51.01%	32.89%
Unemployed	4.49%	81.48%	74.07%	74.07%	44.44%	18.52%
Student (also working)	6.98%	78.57%	73.81%	76.19%	64.29%	50.00%
Student (exclusively)	8.47%	45.10%	54.90%	96.08%	72.55%	35.29%
Decline to respond	5.81%	94.29%	88.57%	57.14%	51.43%	34.29%

Table 1. Classification of the mobility behaviour of respondents by employment situation

Age analysis revealed that the 30-to-45 age segment had almost identical mobility behaviour as the 46-to-55 age segment, except for the use of shared services (Table 2). Again, the first column shows the percentage of people from the sample that belongs to each category. Comparing both segments with the 18-to-29 age group, they had up to 20.73% more driving licences (94% vs 73.27%) and up to 19.20% more car access (89.50% vs 70.30%) and they used public transport up to 26.69% less (54.50% vs 81.19%) and were up to 20.33% less multimodal (46.50% vs 66.83%).

Age	n	Have a driving license	Access or owners of a car	Daily users of public transport	Daily multimodal users	Users of shared services
18-29	33.55%	73.27%	70.30%	81.19%	66.83%	44.06%
30-45	33.22%	94.00%	89.50%	54.50%	46.50%	38.00%
46-55	33.22%	93.50%	88.50%	54.50%	47.00%	19.00%

Table 2. Classification of the mobility behaviour of respondents by age

Between genders, as shown in Table 3, the major difference was with the use of public transport, since women used the public transport on a daily basis up to 17% more than men (72% versus 54.97%). According to Figure 1, the difference regarding the use of public transportation by gender is greater when commuting is out of the city. Although both genders had a much more extensive use of the public transport for moving within the city, females, unlike

males, almost kept this level of use for travelling to the RMB (73.08% vs 47.96%).

Gender	n	Have a driving license	Access or owners of a car	Daily users of public transport	Daily multimodal users	Users of shared services
Male	50.17%	91.06%	86.75%	54.97%	50.00%	35.76%
Female	49.83%	82.67%	78.67%	72.00%	57.00%	31.67%

Table 3. Classification of the mobility behaviour of respondents by gender

In relation to the public transport, as shown in Figure 1, it was considerably more used for the commuters within Barcelona (BCN-BCN) and its immediate than the ones leaving to any location of the metropolitan region (BCN-RMB) or commuters entering the city every day from the RMB (RMB-BCN).

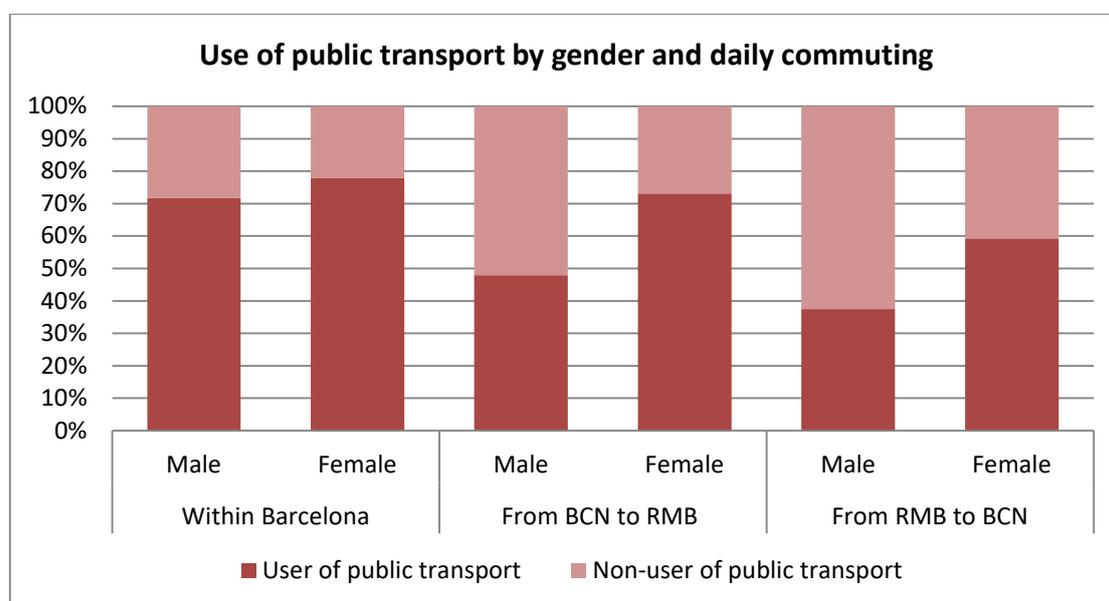


Figure 1. Use of public transport by gender and type of commuting

As shown in Figure 2, the public transport most frequently used was the underground, both for the commuters within Barcelona and its immediate (62.89%) and the ones moving out and in (42.67% and 34.16% respectively). Besides, the citizens that didn't leave the city everyday used significantly more the bus than the others (up to 21% more), whereas commuters moving into or out of the city tend to use more the train - the two companies operating in Catalonia have been considered: RENFE and Ferrocarrils de la Generalitat de Catalunya (FGC) -. According to the interviewees, the main reasons to use the public transport were the stop proximity of the departure point or destination and the avoidance of commuter traffic. In addition, more than a quarter of non-users of public transport (27.65%) didn't take this service

because it didn't reach their location or destination or it was bad connected; another quarter (24.88%) preferred to travel by car and the 11.06% by motorbike; the 14.74% stated that it was uncomfortable, slower, or they were required to make transfers and didn't want to; the 9.22% had their destination within a walking distance; the 4.61% preferred going by bicycle; another 4.61% had incompatible schedules; and the remaining 3.23% pointed out that the public transport stop was too far from their location or destination. According to Figure 2, over half of the commuters leaving and entering the city of Barcelona or its neighbouring municipalities used the car on a daily basis (50.67% and 62.11% respectively), whereas commuters within the city used it with a rate of 28.52%. It is also noteworthy that the use of motorbikes and bicycles by commuters within the city is quite similar (15.12% versus 12.71%).

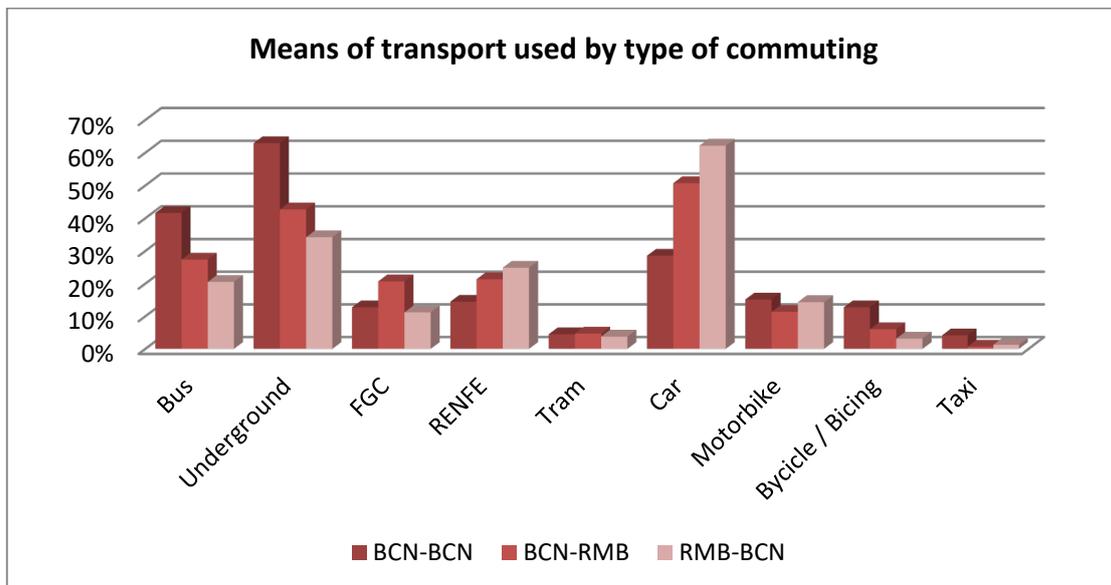


Figure 2. Responses to "Which means of transport do you use to travel in a normal working day" classified by type of commuting

Table 4 classifies the surveyed citizens depending on their use of the public and private transport. From this table it can be seen that, overall, more than 20% of citizens needed not only the use of their private vehicles but also the use of public transport to reach their destinations. This is probably due to the fact that using the private vehicle during part of the trip was faster than only using the public transport, but using the private vehicle until the destination was more expensive in terms of money or time (e.g. need of parking).

Daily transport	BCN-BCN	BCN-RMB	RMB-BCN
Only users of public transport	47.77%	35.33%	26.71%
Only users of private transport	24.74%	43.33%	51.55%
Users of public and private transport	27.49%	21.33%	21.74%

Table 4. Daily transport by type of commuting

Regarding the use of shared services, the 66.28% of interviewees had never used a vehicle sharing or a ridesharing service, the 20.1% had used only one type of these services and the remaining 13.62% had used more than one type of mobility sharing services. As reflected in Figure 3, the most popular mobility service was bikesharing (20.6% of participants had used Bicing), followed by ridesharing (14.62% had used BlaBlaCar), carsharing (6,48% had used Avancar and 1.83% SocialCar) and motosharing (2.49% had used eCooltra, 0.83% had used Yugo and 0,50% had used Motit) - notice that these results were from a multiple choice question -. Among users of mobility sharing services, no difference was observed from a gender perspective, but it was noticeable the difference of behaviours between generations. Only the 19% of participants between 46 and 55 years old had used this type of services, whilst the 38% of participants aged 30-45 and the 44% of participants aged 18-29 had used them (Table 2). The most valued aspect by respondents of mobility services was that these services are cost-saving, and the least value aspect was the limited availability.

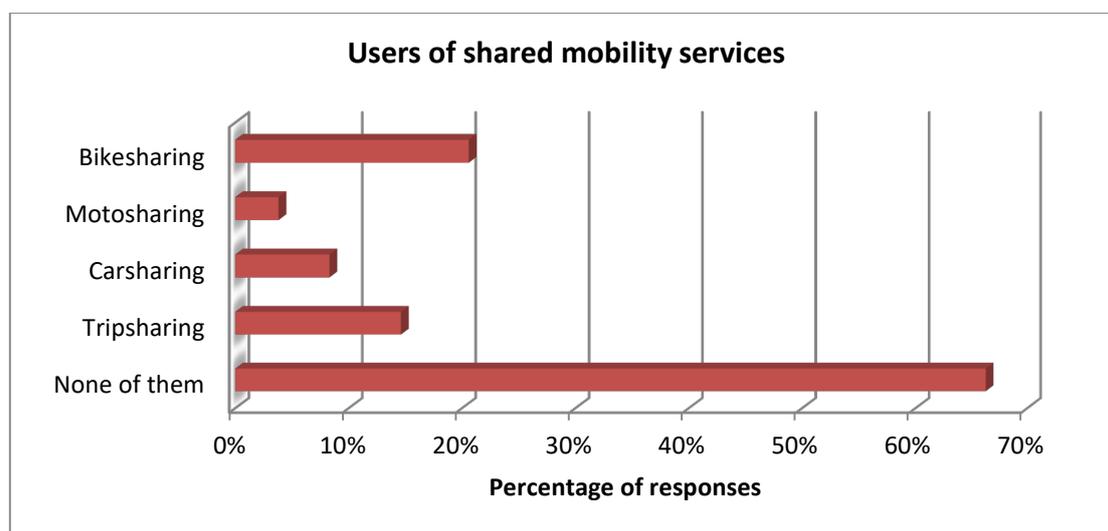


Figure 3. Responses to "Which of the following services have you used at least once?"

Considering the results presented in this section, it can be assumed that the mobility behaviour of the population changes according to the age, gender, type of commuting and employment situation. The youngest population stood out for their use of public transportation, use of shared services and being

more multimodal, featuring a similar behaviour as students. However, the 94.62% of surveyed students aged 18-29. Between genders, women travelled more by public transport than by car, whereas men used more the car, with the exception of commuters within the city.

What will happen in the next years with the emergence of new forms of mobility? Will citizens change their mobility patterns? It is probably too early to foresee it, though it is important to understand citizens' intention to use these new mobility services in order to design their business models.

4.2 Intended use of shared mobility services

Figure 4 provides the histogram of the intention of use of the different shared mobility services considered in the survey. Interviewees expressed their intention of use of the services on a 7-likert scale (Table 5). The histogram reflects that the highest intention of use (sum total of answers 5 to 7) is towards carsharing B2C, followed by singular ride-hailing, ridesharing, shared ride-hailing and carsharing P2P.

Will definitely not use it	Will probably not use it	Will maybe not use it	Indifferent	Will maybe use it	Will probably use it	Will definitely use it
1	2	3	4	5	6	7

Table 5. Rating scale of the services

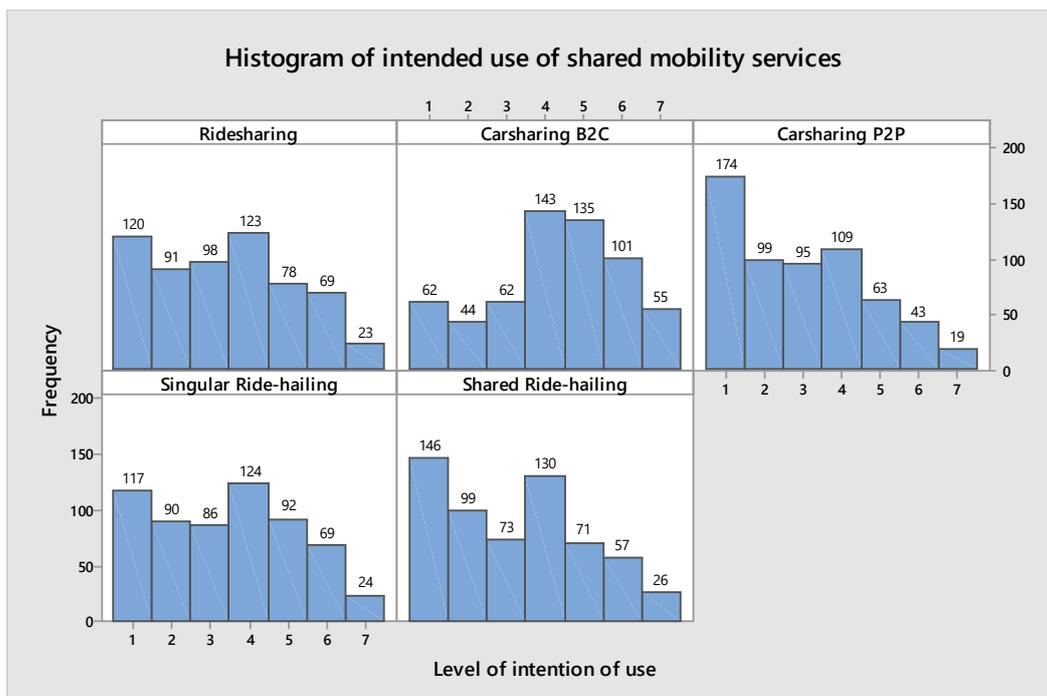


Figure 4. Responses to “If this services were available, to what extent would you be willing to use them?”

In statistics, the medians obtained in all cases (general analysis, study by gender, age, previous experience and commuting locations) are similar enough to their related means, thus indicating that the data analysed has a symmetric distribution with respect to the arithmetic mean. The highest median achieved was for the carsharing B2C and singular ride-hailing (4), which indicates a positive mind-set towards the use of it, whereas the other services obtained a median of 3. These results were common to all age groups and genders. As evidenced, the medians obtained revealed a predominant attitude of uncertainty, possibly associated with the lack of knowledge or user experience. In fact, respondents with a previous experience in any shared mobility service reflected a greater willingness to use them than inexperienced respondents. The analysis of the mode provides, on one hand, the outcome of “will definitely not use it” as the most common intention of use of the different services by previous non-users, with the exception of carsharing B2C, which achieved the result of indifference. On the other hand, previous users of shared services presented indifferences to most of the services except for the carsharing B2C and ridesharing, in which the intentions of “will maybe use it” and “will probably use it” were achieved respectively.

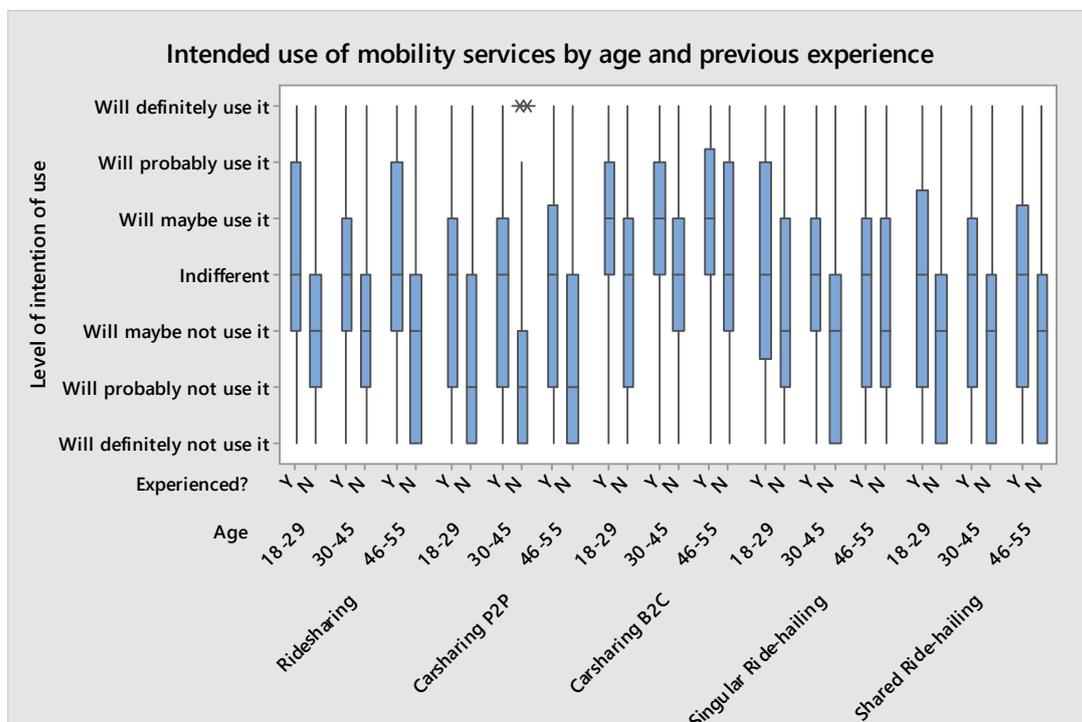


Figure 5. Boxplot of the intended use of shared mobility services by age and previous experience

As represented in Figure 5, age differences were not as significant as having a previous experience with the services studied. Although in each service the

medians are identical for the different group ages, the boxplots indicate small variances in the tendencies, meaning that young population were more predisposed to use ridesharing, P2P carsharing and shared ride-hailing; whilst the tendency in the oldest segment was to use carsharing B2C.

Concerning the intention of use between genders, it was almost identical in relation to the different mobility services studied. On the contrary, the analysis by the type of daily commuting revealed that commuters within Barcelona were more willing to use all of these services than the other commuters, and that the group less predisposed were the commuters from the RMB to Barcelona. As proved in Figure 6, where differences between the types of commuting are not so apparent, it was linked to the previous experience of users, since the 41.92% of commuters BCN-BCN and the 36.67% of commuters BCN-RMB had previously used shared mobility services, and only the 16.15% of commuters RMB-BCN had this experience.

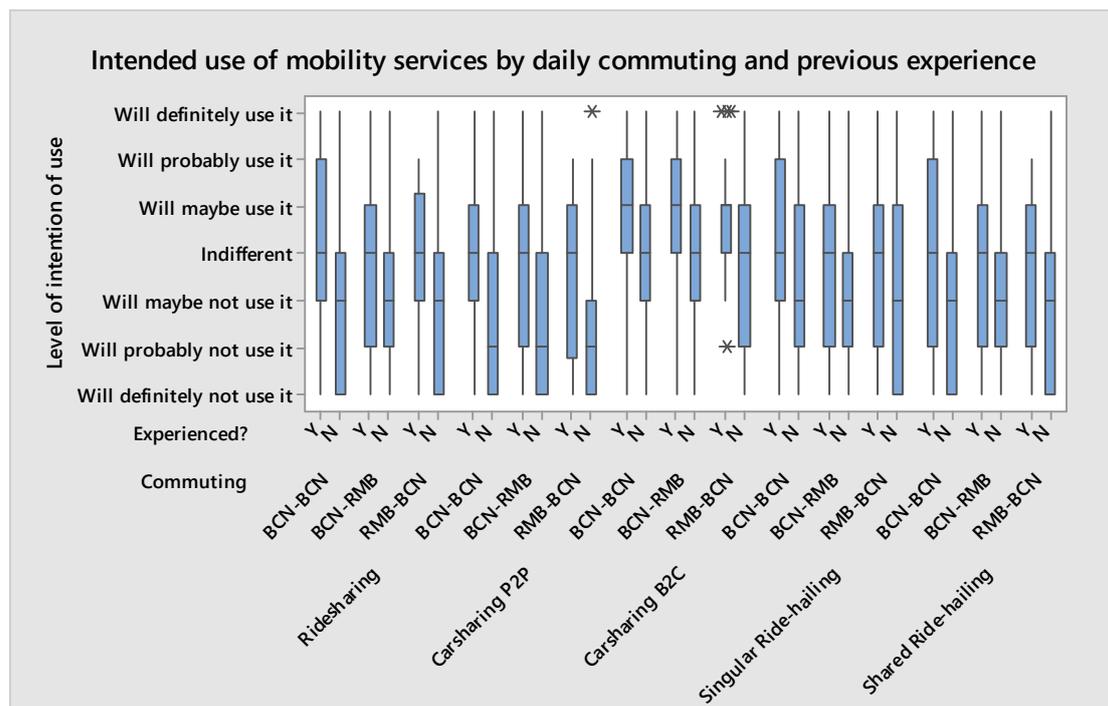


Figure 6. Boxplot of the intended use of shared mobility services by commuting type and previous experience

Anticipating the possibility of a widespread disregard and lack of knowledge, a separate analysis of each mobility service was conducted.

Ridesharing

One-fifth of respondents (19.10%) would use a ridesharing service for long distance journeys (more than 150km) if the cost of the travel was half or less

than travelling by train or by private car. To the question “Which of the following options would you use for long distance trips (more than 150 km): High speed train (30€) - Regional train (21€) - Private car (28€) - Ridesharing (11€)”, the preferred options were, in general, travelling by high speed train (37.38%) and by private car (27.57%), and the least chosen option was using the regional train (15.95%). However, the intended use of ridesharing by already users of sharing services was 8.34% greater than of non-users, preferring this service than going by car (24.63% versus 21.63%). Surprisingly, the age group more willing to use ridesharing was the oldest, as shown in Figure 7; whereas the youngest would use more the regional train and much less the private car. Furthermore, before choosing a ridesharing service, the opinion of other users referred to the respective driver would be taken into account by the 63% of interviewees.

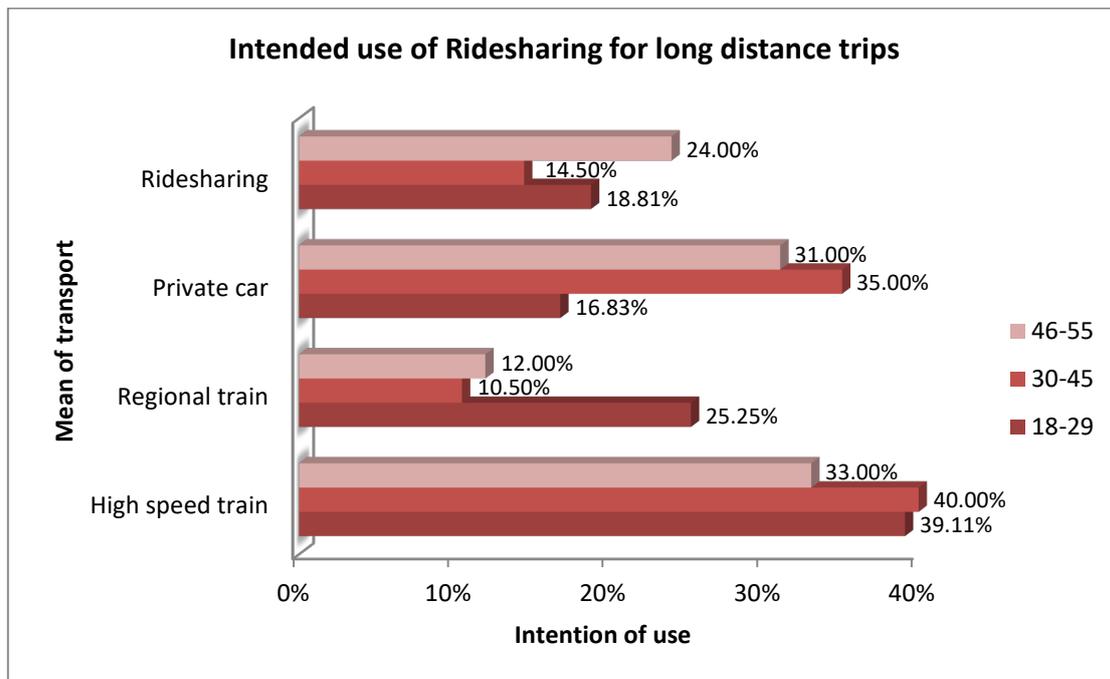


Figure 7. Intended use of Ridesharing by age compared to other means of transport

Carsharing

Two-fifth of respondents (39.7%) would use a carsharing service for one day trip out of the city if they didn't have their own car, preferring a B2C service than a P2P. These results come from the question “In case of not disposing of a car, which of the following options would you find more appropriate for a short day trip out of town (100 km, round trip)? Public transport network - Taxi (130€) - Carsharing B2C (2.5€/h) - Carsharing P2P (38€) - Ridesharing (20€)”. Age analysis reveals that the population aged 30-to-45 and 46-to-55 preferred

carsharing, 19% and 15% respectively more, than the aged between 18 and 29 (Figure 8). In this case, the youngest group would rather use up to 18% more any public transport than the population aged 30-55.

When asked about their preferences regarding point-to-point or round trip carsharing, the 50.83% marked the round trip option, whilst the 42.03% liked both options and only the 7.14% voted for the point-to-point. Besides, only one-fifth of respondents (19.77%) would rent their own vehicles, but again this proportion changes depending on the previous knowledge, increasing up to the 37% if respondents already had a prior experience of using any shared mobility service.

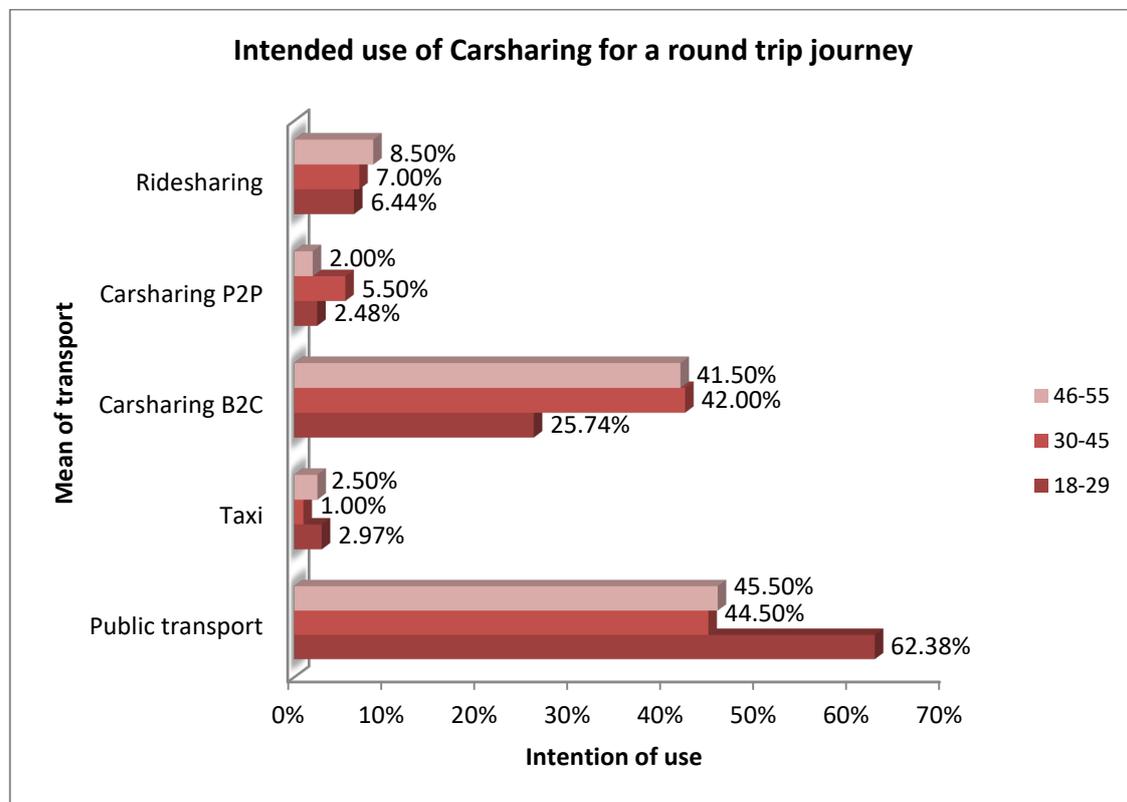


Figure 8. Intended use of Carsharing by age compared to other means of transport

Ride-hailing

On average, taking a taxi was preferred over singular or shared ride-hailing for travelling small distances within the city (31.40% versus 8.97% and 28.07% respectively), when neither the public transport nor the private car were considered. However, in this scenario, 31.56% of respondents would use carsharing. Conversely, the top choice of the youngest was shared ride-hailing, with a rate of 34.16%, as reflected in Figure 9. Figure 9 classifies by age the responses to the following question “In case of not disposing of a car,

and considering that the point of origin and destination do not have a good connection with the underground or the bus, which of the following options would you use for a trip of 10 km within the city? Taxi (15€) - Singular ride-hailing (13€) - Shared ride-hailing (5€) – Carsharing (2.5€/h).

All age groups agreed that for distances over 10-20 km shared ride-hailing was better than the taxi, singular ride-hailing or carsharing. In addition the youngest would not mind to walk up to 6 minutes to the pickup point, but the other age segments preferred a door to door service.

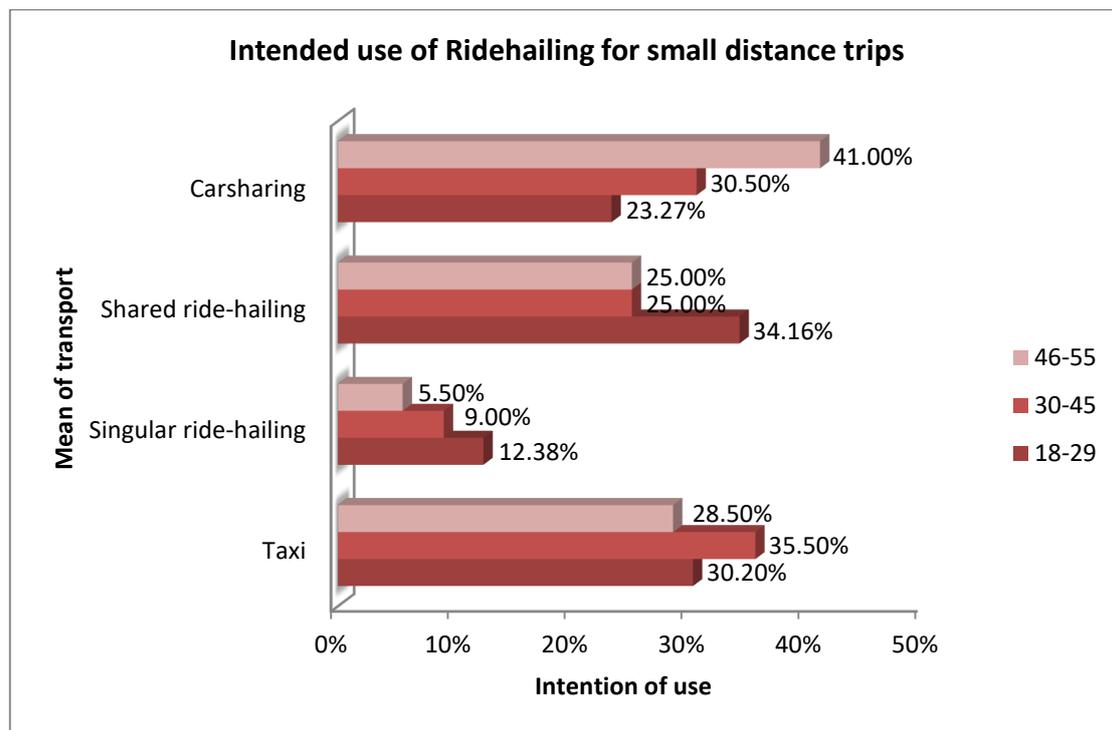


Figure 9. Intended use of Ride-hailing by age compared to other transport services

Cost of the service and payment

Concerning the cost of a carsharing service, participants would prefer to pay for the distance travelled (34.39%) or having a pass in which minutes or kilometers could be charged in advanced with a lower cost (31.56%), rather than paying for the usage time (19.93%) or a monthly subscription for unlimited trips (14.12%).

Paying for the distance travelled is also preferred in the case of singular and shared ride-hailing services, according to the 42.52% of respondents; whilst the 30.9% would prefer to pay a fixed price per zone; the 18.6% would buy a pre-charged pass and only the 7.97% would pay a monthly subscription.

5. CONCLUSIONS

This research was focused on finding use cases and the potential customer profiles of emerging mobility services as the first step to define new business models for new shared mobility services. Results show that citizens aged 18-to-29 are high consumers of public transport and, whenever it is available, they would continue preferring this type of transport over the private car or alternative means. In general, sharing a ride is more attractive for the youngest than driving a car (owned or shared). By contrast, 30-to-45 and 46-to-55 year-old citizens would always prefer to drive than sharing rides. However, the population aged 46-55 show a better predisposition in using ridesharing services than the citizens aged 30-45.

Emerging mobility services are still very unfamiliar to the general public and this lack of knowledge affected the outcoming intention of use, since data indicates that the previous experienced users had a substantially superior intended use in all services analysed. Similarly, the higher willingness identified of younger population and Barcelona inhabitants - out of the city there is hardly any mobility service - towards the use of shared mobility services was proved to be linked with the fact of being more familiar with this type of services.

Findings suggest that shared mobility services should be integrated with each other and with the public transport, since respondents only preferred these services when they could not choice going by car or by public transport. Similarly, more than a quarter of non-users of public transport indicated that public transportation was not an option for them because their area was not or inefficiently covered. On the other hand, more than half of interviewees used daily more than one mean of transport to reach their destinations, and a quarter of them used both the public transport and the private car, under the assumption that the combination of both types of transports was the best travel option in terms of money and time.

Accordingly, the design of integrated shared mobility services as a complement of the existing public transportation could contribute to a better and more sustainable urban mobility. This is aligned with the concept of Mobility-as-a-Service (MaaS) introduced by Whim (Whim, 2016). However, according to the respondents, they wouldn't accept a monthly subscription (as Whim operates) and would prefer to pay for use.



Further research should focus on the needs and expectations of daily multimodal users and, specially, on daily users of both public and private transportation. Furthermore, future research should also investigate about designing a business model which offers a value proposition beneficial for both users and cities.

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