HOW CARSHARING AFFECTS THE TRAVEL BEHAVIOURS OF HOUSEHOLDS?

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INTRODUCTION

Increasingly, cities are aiming towards higher levels of sustainability, by trying to reduce the negative impacts caused by an extensive use of private cars (pollution, congestion). Among various strategies, many efforts are put to promote the use of alternative modes of transportation such as public transit, walking or cycling. Nevertheless, some trips will always depend on the car due to their nature or spatial-temporality. For these car dependent trips, carsharing appears to be an ingenious solution, both from an individual and collective point of view.

While we have seen an increasing interest in this mode both from the research and practical fields, only few studies exist on the collective benefits of carsharing systems. Analyzing socio-demographic features of users and better assessing their overall travel behaviours is a strategic issue. It first is a requirement for carsharing enterprises for development purposes: they need to know who their users are, how they travel with the shared cars and how it fits within the overall travel behaviours of their households. It also is necessary for political and

financial reasons: in fact, estimations of positive effects on CO_2 emissions, car ownership, and congestion, for instance, can help in the recognition process of carsharing as a sustainable mode of transportation. Obviously, the use of carsharing does not affect only the modal choices of the carsharing user, but should also affect the travel behaviours, namely mode choice, of the other members of its household. It is then necessary to gather information on the travel behaviours of the members but also attributes of their households.

In the fall of 2008, a unique opportunity occurred in Montreal (Canada), where Communauto, the first and one of the largest carsharing companies in North America, is operating. A web-based travel survey was conducted towards its 17 000 members along with the 9th large-scale regional Origin-Destination survey. This process provided unique data to compare travel behaviours of carsharing households and of typical households of the area.

This paper is structured as follows. It first presents basic carsharing concepts, and the importance of OD surveys in the Montreal area. Then, the survey methodology is presented, that is the tool that was developed, on the web, to collect travel behaviour data from carsharing households as well as the process required to structure the required databases. It also provides details on the representativeness of the collected sample, and presents a summary analysis of its content. The paper then focuses on the comparison of travel behaviours between carsharing members and similar individual belonging to typical households also surveyed in the fall of 2008. Some conclusions and future research works are finally presented.

BACKGROUND

Basic concepts regarding carsharing services and its role in Montreal are presented along with some details on the conduct of travel surveys in the area.

Carsharing concepts

The inspiration for carsharing is based on an old idea: sharing an expensive resource to allow many to use it without individuals assuming the financial burden on their own. Although it is not a new idea, only recently have carsharing operations shown the potential to increase their market share significantly and play a role in urban transportation. Nowadays, carsharing companies provide car use on request by managing a fleet of vehicles distributed in a number of parking lots called stations. Members have access to any vehicle, at any time, if that they have made a reservation in advance. Thus, users are able to adapt their mobility choices to their particular needs, without the payback notion inherent to car ownership.

This transportation mode relies on the flexibility of the car and fills a gap left by other modes, such as public transit, personal car, and taxi (Britton, 1999, Jemelin and Nicolas, 2007, Millard-Ball and Adam, 2005). In addition, carsharing offers many advantages:

- Both long-term and short-term rental, as well as regular or occasional use;
- Hourly-based reservations, making carsharing more convenient to users than car rental or taxi services;

- Good environmental image and one of the more innovative components of sustainable transportation schemes (Steininger et al., 1996, Goldman and Gorham, 2006).

With these features, carsharing now attracts households that could afford to own a car, but decide not to because they feel that they do not need one on a full-time basis (Communauto, 2006).

A number of studies have been conducted to estimate the potential of carsharing in urban areas and to determine the factors that influence its expansion, like, for instance, population characteristics, advertising, or the creation of a protective carsharing label (Jemelin and Nicolas, 2007, Mariotto and Enoch, 2009, Heling et al., 2009, Ohta et al., 2009, Clavel et al., 2009). Other research works deal with changes in transportation behaviors when a carsharing service is available (Shaheen, 2001, Cervero et al., 2002, Chin and Lee, 1998, Douma and Gaug, 2009). Cervero et al. (2002) state that this transportation mode could attract more users towards individual car ownership in the San Francisco area. Other authors indicate otherwise, maintaining that users are abandoning car ownership to join the system, and hence contributing to the decrease in car ownership (Millard-Ball et al., 2005, Shaheen and Cohen, 2008). Since many studies are based on declared behaviors or on sample analysis particular to specific areas, results may have to be considered with caution. Although the effects of carsharing are well anticipated (Millard-Ball et al., 2005, Fellows and Pitfield, 2000), there is a need for more extensive scientific validation.

Information system

Large-scale Origin-Destination travel surveys have been conducted for more than 40 years in the Greater Montreal Area. Since 1970, nine surveys have been held approximately every 5 years, with a 5% sample of the residing population. The survey questionnaire focuses on three main objects: the household, the people and the trips. These large scale phone surveys allow gathering detailed information on every trip performed by people aged 5 years and older during one specific day of the fall period. In 2003, the survey collected data on about 400,000 trips made by 165,000 people gathered in some 70,000 households.

Simultaneously to the latest survey that was conducted in the fall of 2008, a web-based survey experiment was conducted among the members of the Montreal carsharing company, Communauto. Communauto has awakened the North America to carsharing in 1994. Since then, it has grown to be one of the most important systems on the continent and is still growing at a fast pace. It now has more than 20,000 members and is operating a system of more than 1000 cars.

In order to provide unique comparative data on the travel behaviours of carsharing members, a web-based survey was developed based on the typical large-scale travel surveys conducted in Montreal. This experimentation had two main objectives:

- To prototype and test a web-based transposition of the current CATI-based questionnaire used for the large-scale regional travel surveys;
- To gather one-day trip diary for carsharing members, the attributes of their belonging households and some info on the daily travels of all the household members; such data to be used for travel behaviours comparison.

METHODOLOGY

More details on the data collection process are provided in this section; steps of the database processing are also presented.

Data collection

In order to allow comparison with the regional population, the survey focusing on Communauto members was conducted at the same time as the large-scale regional Origin-Destination (OD) survey. While the 9th regional OD survey occurred in the fall of 2008 (September through December), the survey toward Communauto members was online from September 17th to November 30th.

Instead of phone interviews, as for the large-scale regional survey, Communauto chose a web-based survey. This decision was based on two main reasons: limited resources for tool development and the familiarity of Communauto members with Internet and their typical survey tool. According to Communauto satisfaction surveys, about 90% of Communauto members reserve their car with Communauto web-booking software.

The web questionnaire was developed with a particular commercial survey software. This tool was chosen for its simplicity and because Communauto was already a registered user. The questionnaire was developed with three main objectives: 1) conforming as much as possible to the regional OD survey, 2) being as succinct as possible, and 3) being as simple as possible.

Yet, the tool had some limitations that further complicated the development of the questionnaire, and the anticipated quality of responses. First of all, the software did not allow for loops within the questionnaire, a function that would have been useful because questions are the same for each people of the household, and for each trip of each person. Therefore, the questionnaire is made of more than 200 questions instead of about 20. Figure 1 illustrates the questionnaire's framework without loops, for a household of two people with two trips per person. In reality, the questionnaire allows a maximum of 6 trips per person for 6 people in a household. Sioui et al. (2009) describe the survey process and tool.
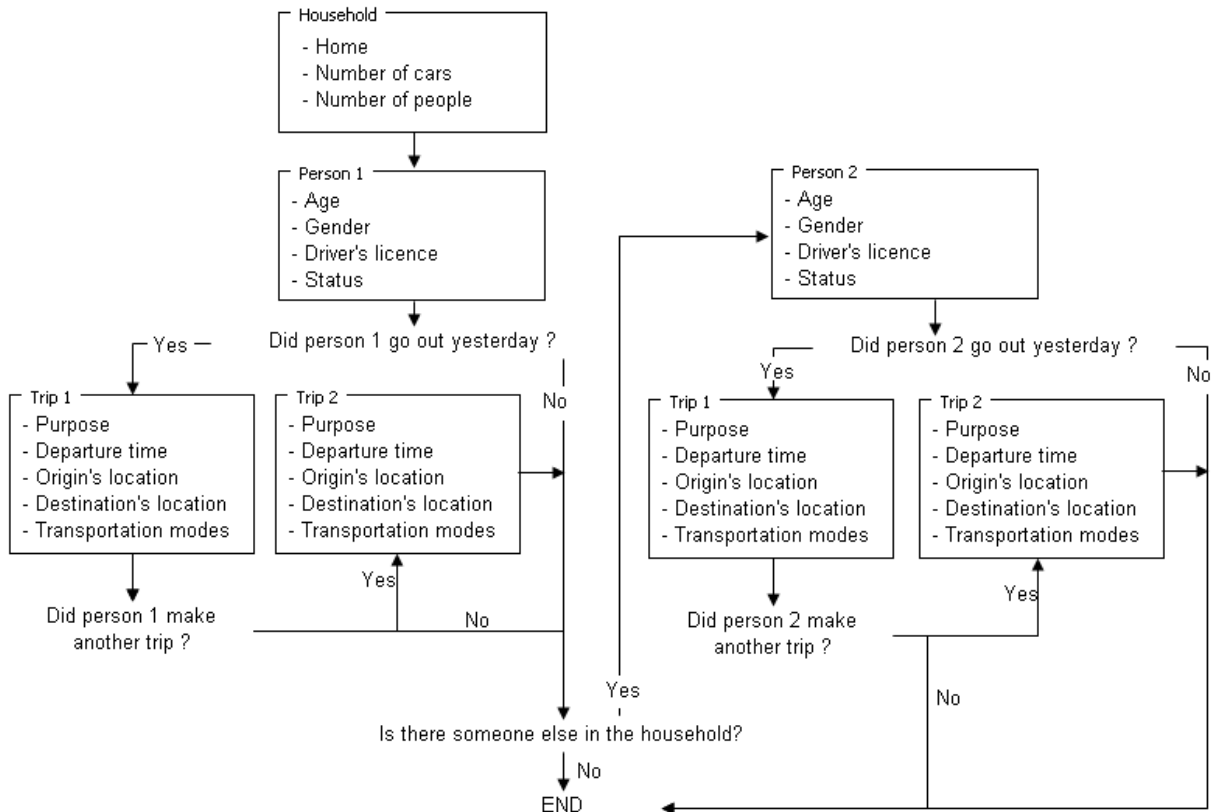
Figure 1. Questionnaire's framework without cycles (Sioui et al., 2009)

Also, the survey tool had other limitations, such as no back button, no re-use of answers, no automatic coherence validations between answers, etc. Still the survey was conducted among the users and allowed gathering relevant information.

Database processing

Construction of the Communauto members database

In order to evaluate the representativeness of survey respondents, the sample has to be compared with the features of all Communauto members (survey universe). The basic hypothesis is that the target population includes all Communauto members living in the Greater Montreal Area (GMA).

For validation purpose, we used a member's database of September 2009 that includes all people there were once members. This database includes both previous (no longer members in the fall of 2008) and new members (that started after the fall of 2008).

For each member, the available database gives information on subscription and cancellation dates, birth date, and postal code of home location (PC). Thus, the target population for the web-based survey conducted during the fall of 2008 is defined as all members living in the GMA that subscribed to Communauto before November 30th and that did not cancel their subscription before September 17th, if applicable.

For further analysis, the age of members, at the survey period, is needed and derived from birth date. Yet, because the questionnaire was online more than one single day, the age of people may have change between the beginning and the end of the survey. Then, a reference date was set for imputation: 2008, October 31st, which is in the middle point of the online survey.
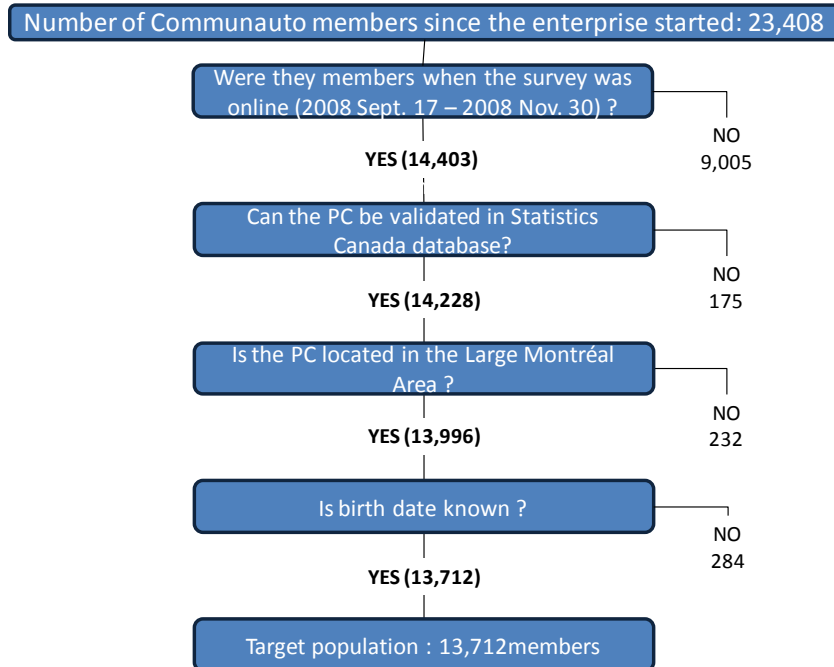

Figure 2. Definition of target population for the web-based OD survey conducted toward Communauto members

Overall, the target population includes 13,712 Communauto members. Members with no birth date were excluded in order to simplify further treatments on representativeness.

Construction of the survey respondents database

First of all, to be part of the analysis, two items are required: 1) the member ID and 2) the home location (postal code). Normally, the web tool automatically registers the member ID, but some mistakes occurred and 85 questionnaires have no member ID. Also, some member IDs that were automatically registered during the survey were not validated with the Communauto members database.
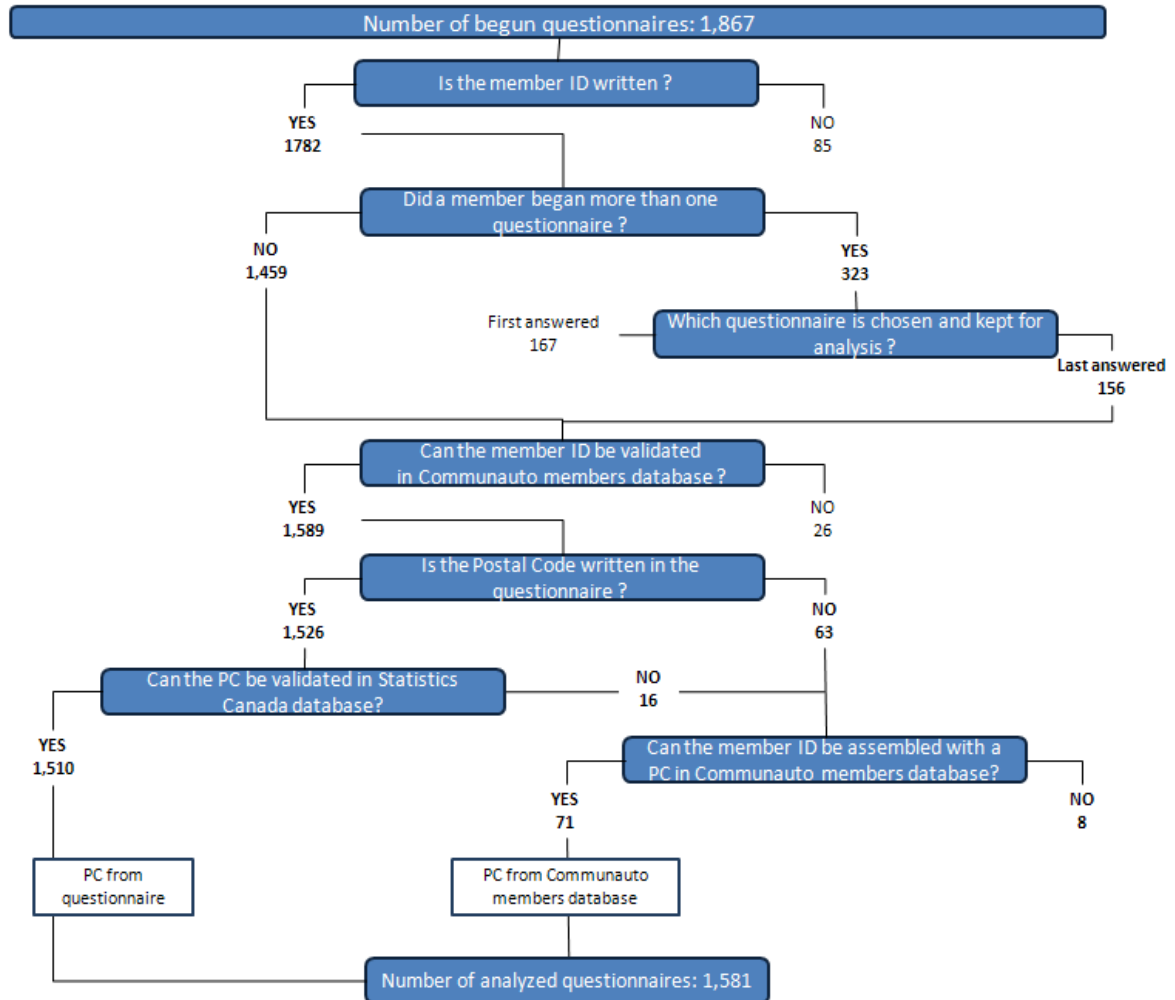
Figure 3. Methodology selection of analyzed questionnaires

Concerning the postal code, even though this information is available in the Communauto member's database, survey respondents had to provide it in the questionnaire. If unwritten by a survey respondent or invalidated by Statistics Canada (the postal code does not exists), an imputation using the Communauto member's database is done. Yet, this latter option creates a degree of uncertainty, because these survey respondents may have changed their home location between the fall of 2008 and September 2009. This reason is also why the written postal code has not been systematically validated with the one in the Communauto member's database.

Moreover, some respondents have answered the questionnaire more than once. For these, questionnaires have to be examined to decide which one is kept for further analyses. In this study, the hypothesis is that the latest attempt is more relevant since members probably figure that their previous attempt was incomplete or erroneous. This hypothesis could be refined using various tests on the collected information. Statistics on these multiple questionnaires shows that only 37% of them have been completed the same day. For 82% of these, the last questionnaire is more fully completed, which means that it is consistent to keep the latest for analysis. Other multiple questionnaires (63%) were completed at two different days, and only 42% of these were less completed than the last one. This reveals

that some Communauto members may have gone twice to the web-booking reservation, and so completed the questionnaire twice during the fall of 2008.

SAMPLE ANALYSIS AND RESULTS

This section first analyzes the representativeness of the collected sample (1,581 analyzed questionnaires), and then compares some characteristics of Communauto households, people and trips with the typical population.

Sample representativeness

Representativeness of survey respondents with respect to all Communauto members can be analyzed in terms of demographic features, frequency of carsharing use, and home location.

Demographic representativeness

Sample representativeness is not equal among age (Figure 4**Erreur ! Source du renvoi introuvable.**). Youngest members (from 16 to 19 years old) are highly represented but are quite few. Also, oldest members (from 55 to 88 years old) answered less than the other age groups. Sampling rate varies between almost 14% to around 4%.
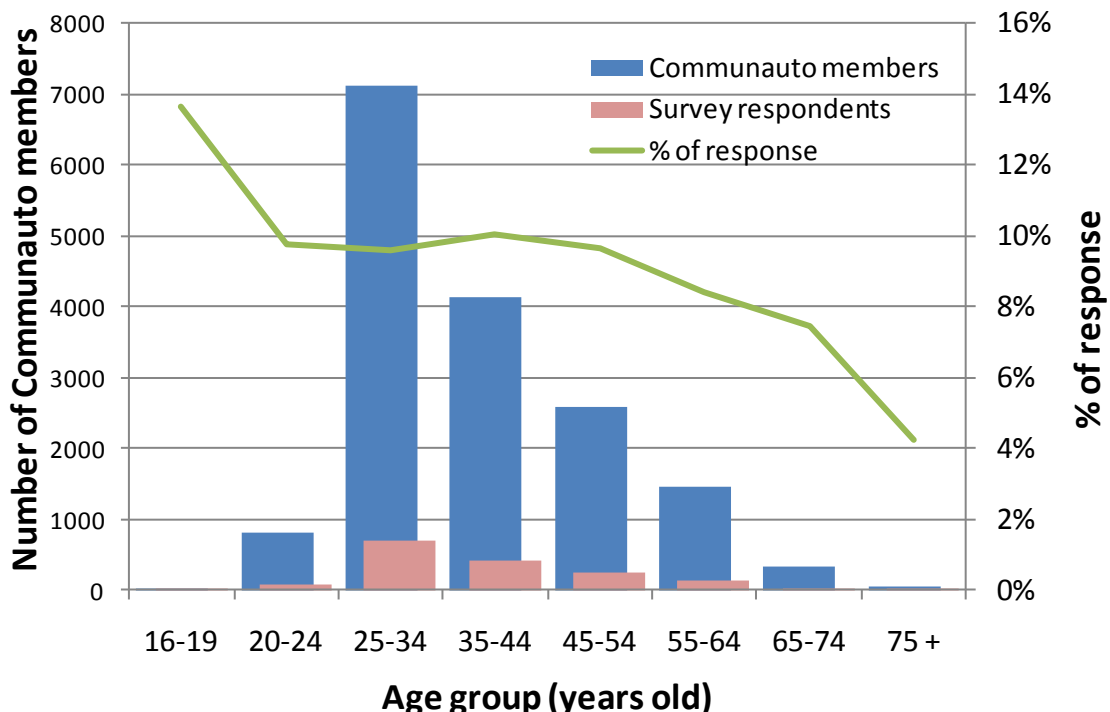

Figure 4. Age representativeness of survey respondents

These observations were expected for a web-based survey, because youngest people are friendlier with Internet than oldest. Still, the sampling rate is acceptable for all cohorts.

Carsharing service use representativeness

Among the 13,712 Communauto members considered, almost 25% did not use a Communauto car during the 2008 year. Only 4% of these inactive users answered to the web-based travel survey. Figure 5 shows the representativeness of survey respondents according to the average number of transactions in a week, during the year of 2008.

For Communauto households, a distinction has been made regarding the level of use of the shared cars. For this paper, it has been established that inactive Communauto members did not use the carsharing service during 2008, limited members use the service between 0 and 0.5 time per week, medium users between 0.5 to 1.5 times per week, and high users booked a car more than 1.5 times per week.
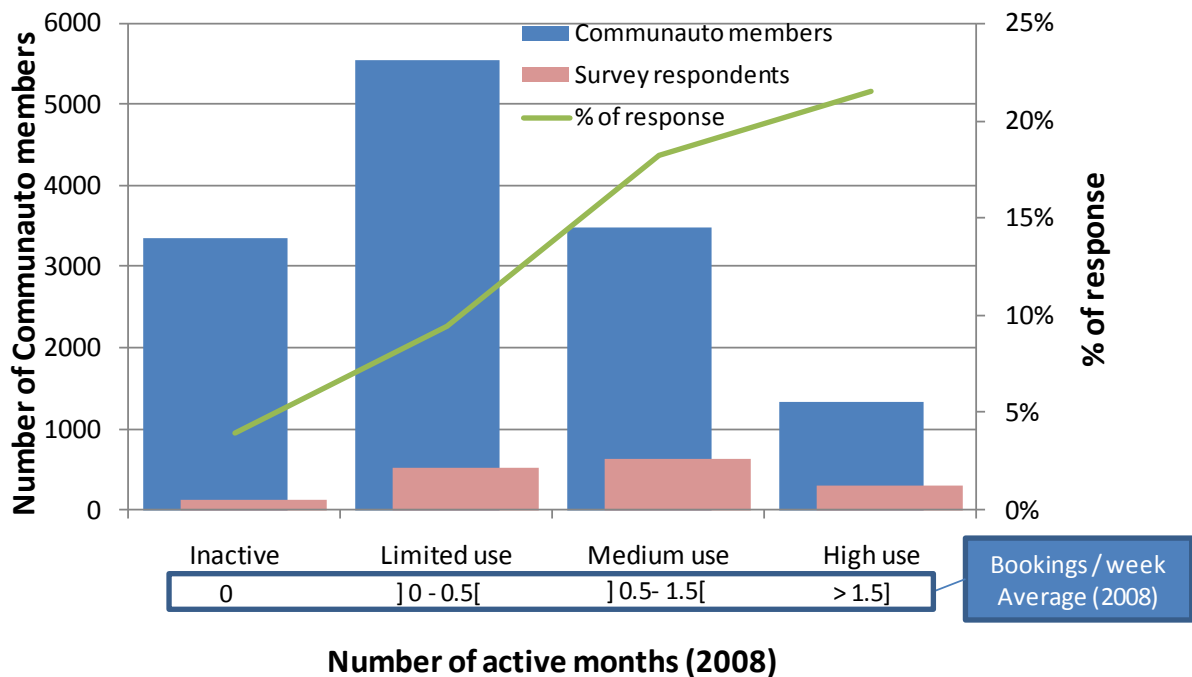

Figure 5. Carsharing service use representativeness

This illustration clearly shows that people who have a higher level of use of the carsharing service participated to a higher degree to the survey. This was anticipated since the link to the OD survey popped up every time a member went to book a car through the web site. Nevertheless, some members that are not frequently using the carsharing service have answered to the survey. This may be explained by the fact that the web-based travel survey was also promoted in the Communauto monthly letter.

Spatial representativeness

Survey respondents do not equally cover the Communauto members living area. Also, some areas contain too few Communauto members, and so not enough survey respondents. Thus, areas with less than 25 respondents are excluded. Figure 6 shows the response rate in many municipal sectors, which varies between 5.4% and 11.1%.
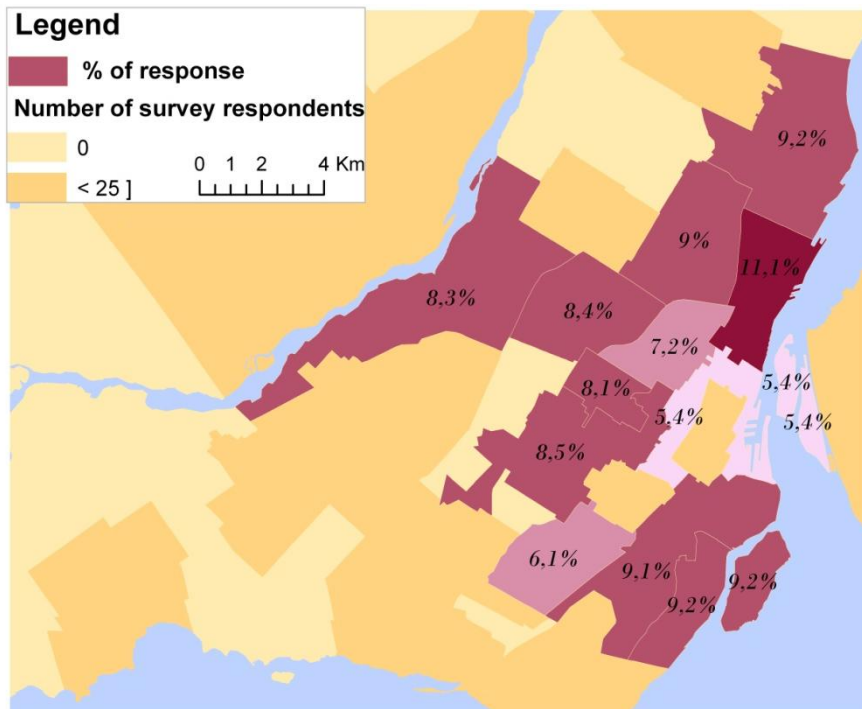
Figure 6. Spatial representativeness of respondents

Chosen questionnaires for analyses and response rates

For the next analyses, survey questionnaires are kept if their respondents:

1) are between 20 and 54 years old;

2) have their home location in sectors where sampling rate is higher than 5%.

Regarding the frequency of carsharing use, all respondents are kept. This will allow splitting the analyses by carsharing activity level. Hence, 1,311 questionnaires are kept, which represents 1,311 households, 2,814 people, and 3,589 trips. As showed in Figure 7**Erreur ! Source du renvoi introuvable.**, response rates are often more than 90%. Though, the occupation of people has lower response rate with 63.7% of people providing answers.
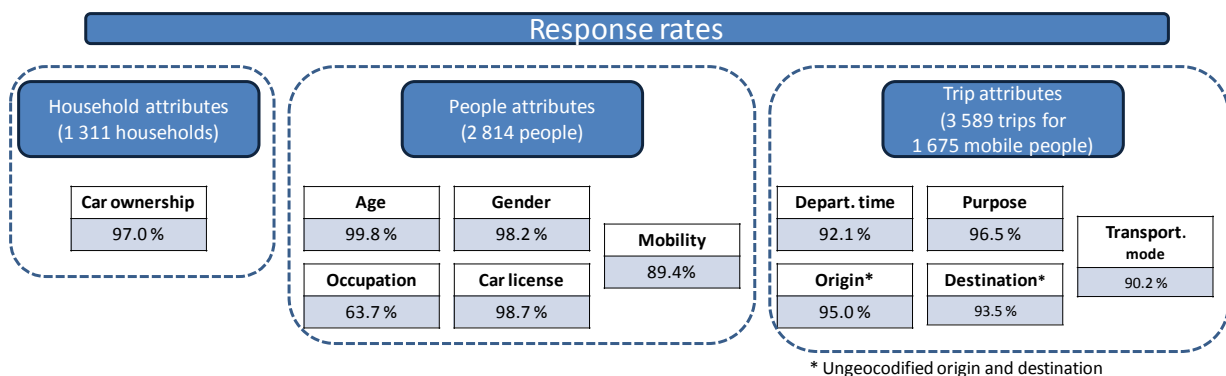

Figure 7. Response rates of Communauto web-survey questions

Due to many open-box questions, some imputations and corrections have been made. First, some answers were incorrectly written by survey respondents, but still understandable and possible to categorize. This is the case for departure time of trip, driving license ownership

and occupation of people, for which a complete review of answers allowed to enhance response rate. Second, some questions can be partly validated, as driving license ownership, which is impossible for people under the age of 16 years old. Partial validation is also possible for the age of the first respondent of each household, which should be the same as in the Communauto member's database.

Origin and destination of trips still have to be reviewed and, when enough information is written, a geocoding method is applied to these locations.

Comparison of Communauto members and their household with the typical population

In this section, some figures and statistics are presented in order to better understand the characteristics of households with at least one carsharing member, people living in these households, and the transportation modes they use. An emphasis is made on the comparison with the regional large-scale OD survey in Montreal (2008). For these analyses, it was decided to compare households in which at least one person is a Communauto member ("Communauto household", CH) with "OD survey household" (hereafter called "Montreal households", MH) with similar characteristics, that are located in the same municipal sectors and with at least one member between 20 and 54 years old in their household.

Households

The collected sample gathers 1,311 households. Concerning the household size, even though single people are about in the same proportion between Communauto and OD survey households, Communauto members seem to live more in 2 people households, being 44% of CH compared to 33% of MH[1] (Figure 8).
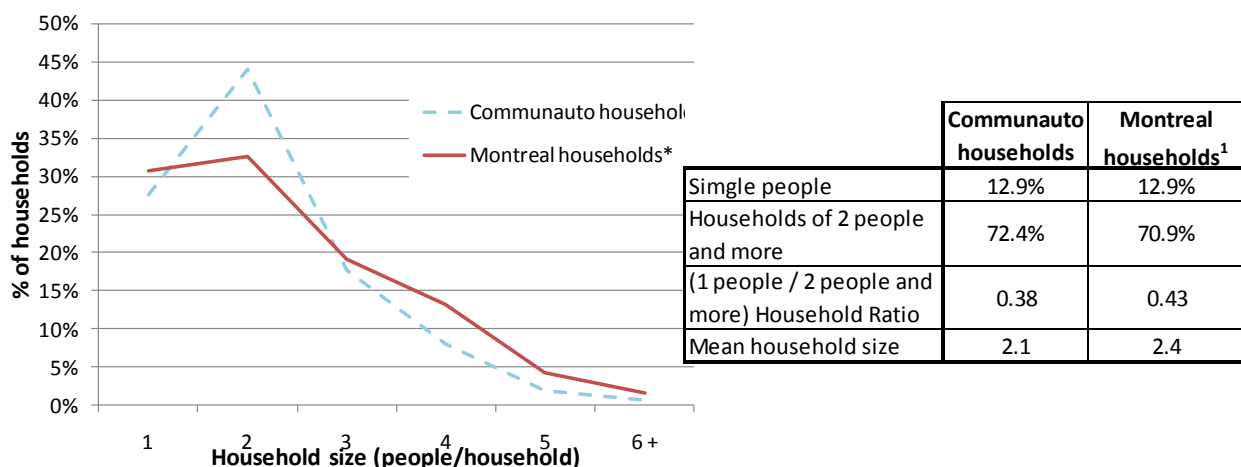

	Communauto households	Montreal households[1]
Single people	12.9%	12.9%
Households of 2 people and more	72.4%	70.9%
(1 people / 2 people and more) Household Ratio	0.38	0.43
Mean household size	2.1	2.4

Figure 8. Comparison of household size

[1] Montreal households located in the same municipal sectors selected for Communauto sample and with at least one member between 20 and 54 years old.

Moreover, much bigger households (3 people and more) are more common in MH. Therefore, the mean household size is a bit greater for this group.

Communauto household car ownership is 0.13 car/household, which is a lot less than the one for Montreal households with 0.89 car/household.
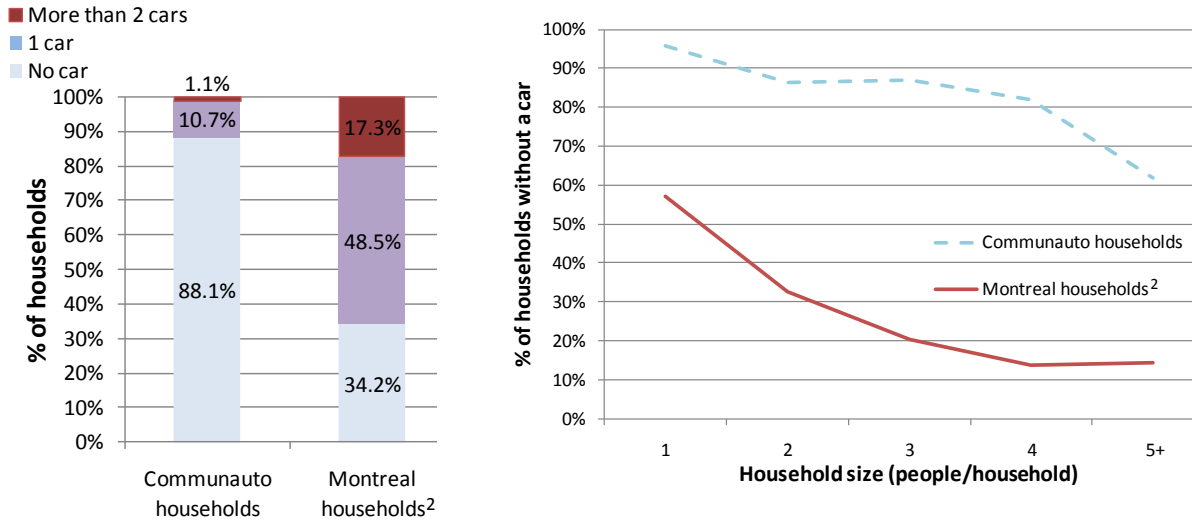

Figure 9. Comparison of household car ownership

In the general population, household car ownership is greater for all household sizes. Hence, Communauto households possess fewer cars than the general population (Figure 9).

Regarding the carsharing service use, sampled households are mostly: (1) non-motorised single people (26% of sampled households), (2) two adults without a car (33% of sampled households), and two adults and a child without a car (11% of sampled households).
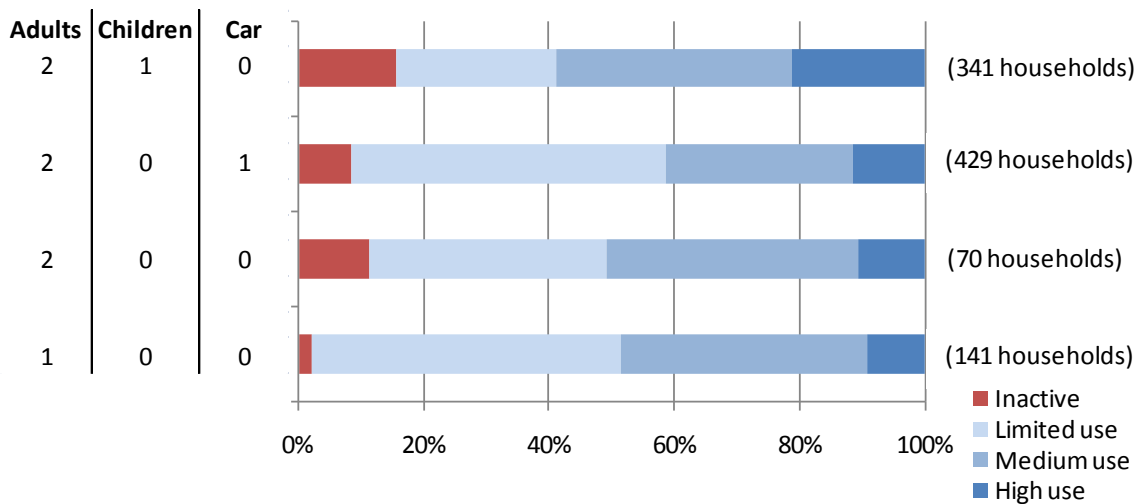

Figure 10. Shares of carsharing service use for different type of households

Figure 10 shows that single people households use carsharing services fewer than non-motorised two-adults households. Non-motorised two-adult households seem to be more active when they have a child. Also, almost 60% of the motorized two-adult households are inactive or limited users.

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People

An OD survey also gathers information on people living in surveyed households, that is 2,814 people in this study. People living in Communauto households are more present between 20 and 39 years old. Young (0 to 19 years old) and old people (40 to 99 years old) are more represented in MH[2] (Figure 11). This goes with the previous observation on much larger MH[2]: they may be composed of more than one children or an old family member.
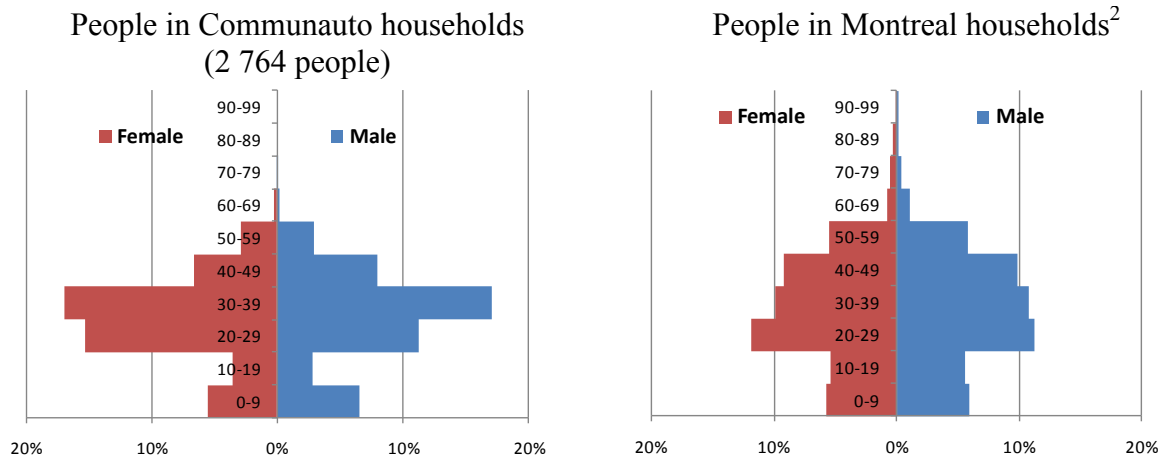

Figure 11. Comparison of demographic distribution

Figure 12 compares the occupation of people between CH and MH[2]. Full-time workers and children of less than 5 years old have a greater share in Communauto households than in Montreal households[2]. Yet, retired and students are much less present. This information follows the trends showed in the previous demographic distribution (Figure 11). Children living in a Communauto household are younger, with an average of 6.5 years old compared to 8.3 in Montreal households[2].
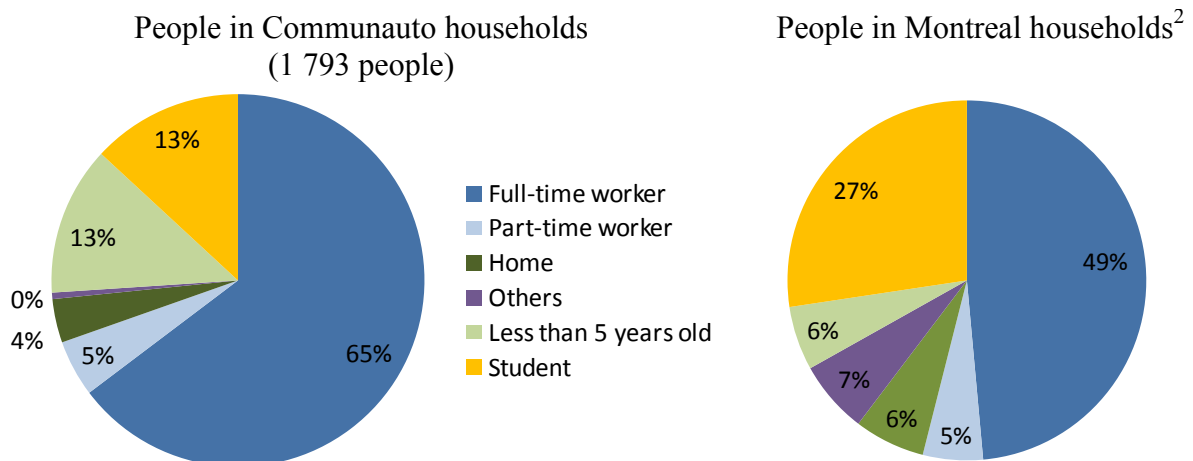

Figure 12. Comparison of people occupation

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[2] Montreal households located in the same municipal sectors selected for Communauto sample and with at least one member between 20 and 54 years old.

Moreover, 85.1% of people in Communauto households (16 years old and more) possess a driving license, compared to 73.4% in MH[3]. This seems paradoxal, but people in Communauto households still make fewer trips than in MH[3]. As much as 27.9% of them do not move during week days (12.8% in MH[3]), and CH make 1.6 trips per day per person instead of 2.2 in MH[3].

Trips

This web-based survey allowed gathering 3,589 trips made by 1,675 people in 1,020 households. This section will focus on modal split comparison.

First, single people without a car represent 26% of Communauto households. 68% of these people made at least one trip during the interviewed day. It is possible to compare modal split for trips of single Communauto households without a car to similar Montreal households[3], with no or one car (Figure 13).
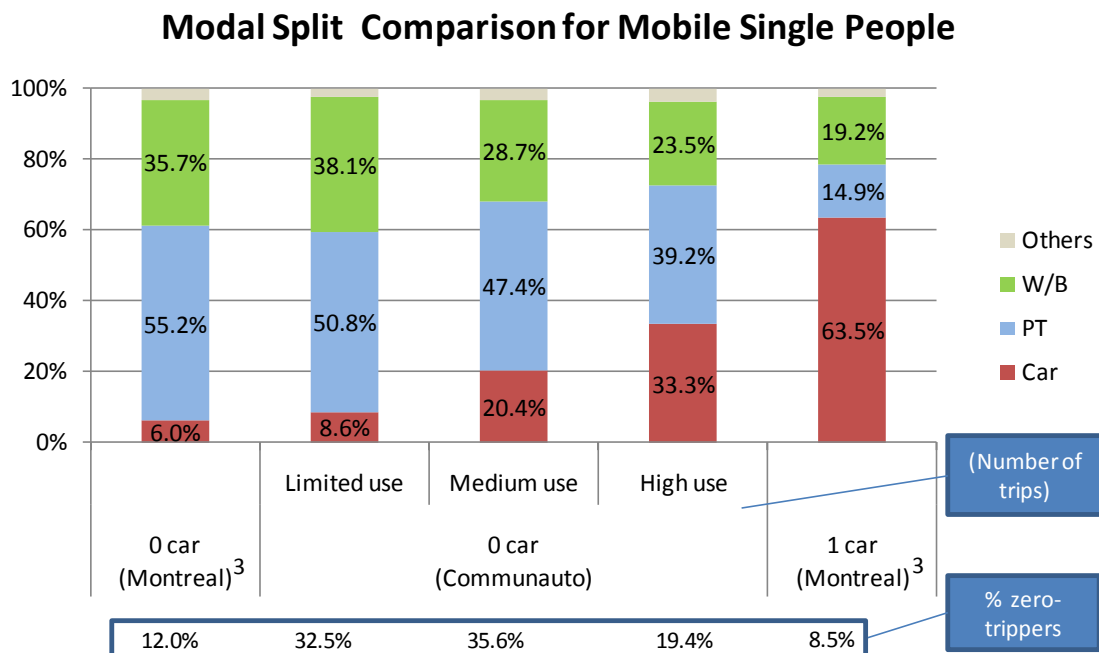

Figure 13. Modal split comparison for single households (W/B = walk & bike, PT= public transport)[3]

Figure 13 shows very interesting trends. First, people with the lowest car share are the non-motorised ones. The Communauto members, using the service a limited number of times, have higher car share but also higher active transportation shares. Then, car share increases with the frequency of usage of Communauto cars but never to the level of a similar person who owns a car, suggesting a more efficient use of the car and of the other alternative modes of transportation, namely transit. Between being a fully motorised person or being a high frequency Communauto member with no car, stands a 30% difference in car share during a typical day of travel. And the difference gets higher with the decreasing frequency of use of carsharing services.

[3] Montreal households located in the same municpal sectors selected for Communauto sample and with at least one member between 20 and 54 years old.

A similar analysis was conducted for two-person households with varying degrees of car ownerships and carsharing usage (Figure 14). Again, a clear trend in car share is observed in the daily mobility with respect to car ownership. First, the people living in non-motorised households have the lowest car share. Then, the car share increases with the typical frequency of use of the communauto system but never up to the level of a person living in a mono or multi-motorised households. When comparing people with high use of the carsharing system and those living in a household owning one car, the car share is twice as high and triples if the belonging household has 2 cars[4]. The impact is significant. Again, it suggests that the private availability of one or two cars, within a household, is a determinant incentive to use the car more intensely and to make less frequent use of other available modes of transportation, and car share increases as the frequency of use of carsharing services increases.
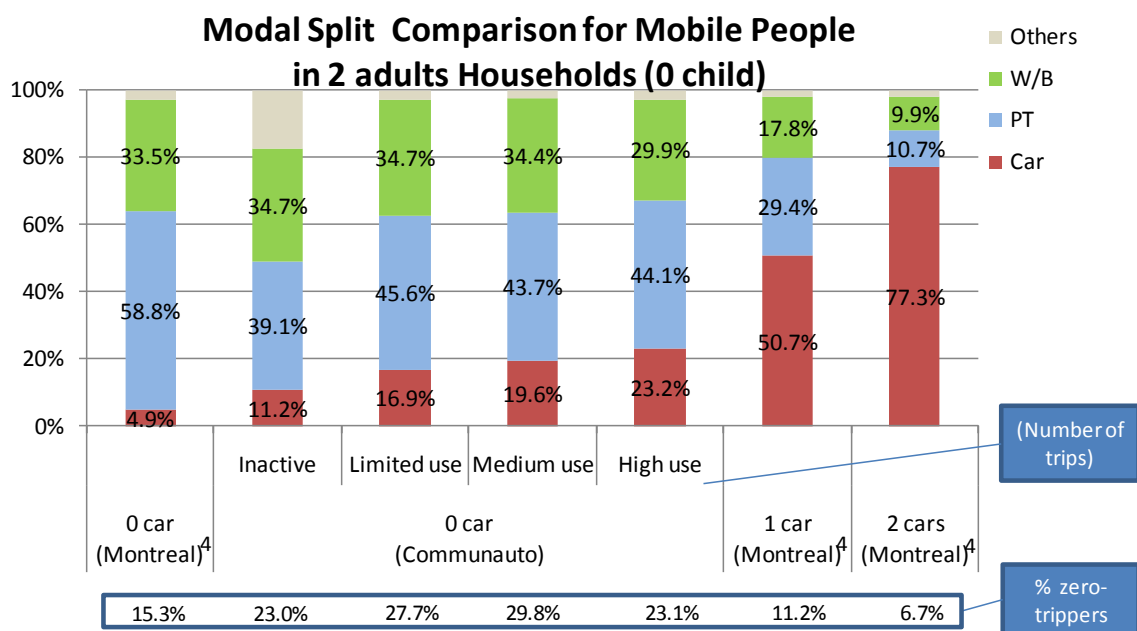

Figure 14. Modal split comparison for 2 adults households without a child (W/B = walk & bike, PT= public transport)

Figure 15 shows the spatial distribution of the differences between car shares of people living in 2-people households based on their car ownership and carsharing usage. In more details, it shows the ratio between car share of carsharing members with limited or medium use level of Communauto and those living in household owning one car. Hence a ratio of one would mean identical shares of car use and increasing difference with reducing ratio. This map reveals that the ratio between CH and MH[4] is greater close to downtown. This means the difference of car usage between CH and MH[4] increases when going further to downtown.

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[4] Montreal households located in the same municipal sectors selected for Communauto sample and with at least one member between 20 and 54 years old.
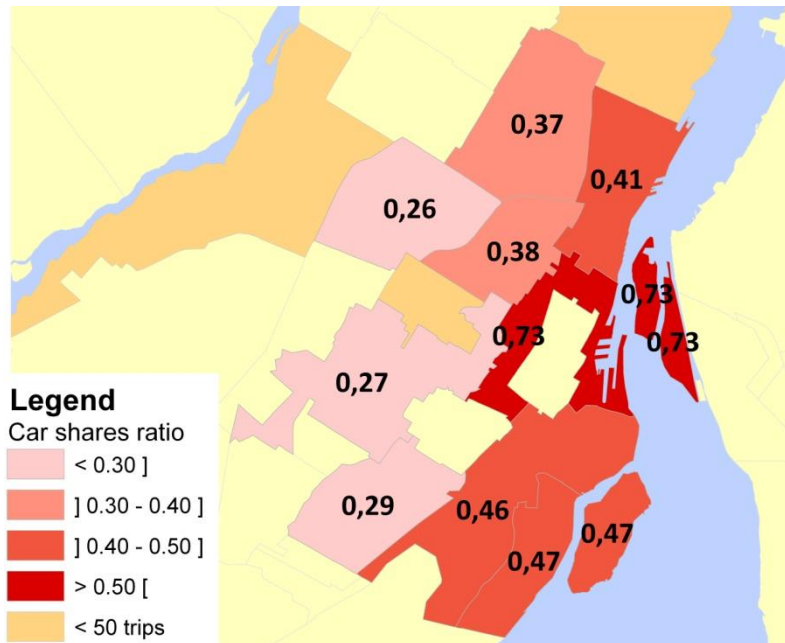
Figure 15. Car shares ratio (trips made by people living in 2 people Communauto households having a limited or medium frequency of use of carsharing services / trips made by people in 2 people montreal households[5] owning 1 car)

CONCLUSION

This paper has presented a survey methodology that was developed to gather trip data from a particular population segment: the carsharing members. The survey tool that was developed along with the typical regional travel surveys held in the Montreal area were presented. A description of the sample that was gathered using the web-based tool was proposed and the key figures were compared with two set of data: typical people of the region and various types of carsharing members.

Even if the collected sample was not representative of the entire set of members, some comparisons between travel behaviours, based on a one-day trip declaration, were conducted. Attributions of the belonging households as well as demographic features of the traveller were used as classification variable to conduct the comparison.

Modal share was used as a first travel-related indicator. Results show that non-motorised households have the lowest car share and that car share increases with the type of carsharing member (from non frequent to very frequent users). Still, it shows that notwithstanding the level of usage of the carsharing members, car share never rises to the level observed for similar households owning one car or more. These results suggest that households needing a car for some parts of their daily trips will make more efficient use of the car by being carsharing members with comparison to those who actually own a car.

In the near future, the comparison of behaviours between carsharing membres (and their households) will be pursued using other travel indicators. The geocoding and imputation of

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[5] Montreal households located in the same municipal sectors selected for Communauto sample and with at least one member between 20 and 54 years old.

trip ends will be assured, using similar tools and reference datasets that those used during the large-scale regional surveys and this will allow to estimate travel distances by modes of transportation. Trip chaining will also be examined in order to see if organisational patterns are similar.

ACKNOWLEDGEMENT

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