How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada

Louiselle Sioui, Catherine Morency & Martin Trépanier

To cite this article: Louiselle Sioui, Catherine Morency & Martin Trépanier (2013) How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada, International Journal of Sustainable Transportation, 7:1, 52-69, DOI: 10.1080/15568318.2012.660109

To link to this article: http://dx.doi.org/10.1080/15568318.2012.660109

Published online: 27 Sep 2012.

Submit your article to this journal

Article views: 600

View related articles

Citing articles: 15 View citing articles
How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada

Louiselle Sioui,1 Catherine Morency,1 and Martin Trépanier2
1Department of Civil Engineering, École Polytechnique de Montréal, Montréal, Québec, Canada
2Department of Industrial Engineering, École Polytechnique de Montréal, Montréal, Québec, Canada

ABSTRACT
Although carsharing is spreading across the world, few studies have examined its collective benefits. There is a need to analyze the socio-demographic features of users, and assess the role and impact of carsharing on the overall travel behaviors of their households. This article compares the results of two simultaneous surveys in the Montréal area: a web-based survey among carsharing users; and a regional, large-scale household travel survey. Results show a significant difference in modal split of car use between carsharing users and typical residents, for various types of households and levels of carsharing use. In all cases, carsharing members never reached the level of car use observed in the population.

Key Words: carsharing, travel behavior, travel survey, web-based survey

INTRODUCTION
Increasingly, cities are aiming towards higher levels of sustainability, in part by attempting to reduce the negative impacts of the extensive use of private cars (pollution, congestion). Among the various strategies are the many efforts made to promote the use of alternative modes of transportation, such as public transit, walking, or cycling. Nevertheless, some trips will always be car-dependent, due to their nature or their spatio-temporal location. For these trips, carsharing—a service offering direct access for its members to a fleet of cars distributed throughout an urban area, which is less costly than owning a car and more flexible than...
conventional car rental—appears to be an ingenious alternative, both from an individual and a collective point of view.

While we have seen an increased interest in this mode of transportation, both in the research and practical fields, only a few studies have looked at the collective benefits of carsharing systems. In doing so, analyzing the socio-demographic features of users and better assessing their overall travel behaviors are important strategic issues to be addressed. In fact, such an analysis is a requirement for carsharing enterprises for development purposes: they need to know who their users are, how they travel in the shared cars, and how carsharing fits within the overall travel behaviors of households. It is also necessary for political and financial reasons. Estimating the positive effects on carbon dioxide emissions, car ownership, and congestion, for instance, can help move the process of recognizing carsharing forward as a sustainable mode of transportation. Obviously, carsharing affects the mode choice of the carsharing user. It should also affect the travel behaviors, in terms of mode choice, of the other members of the user’s household, which is why it is also important to gather information on the travel behaviors of the members of the household.

During the fall of 2008, a unique opportunity presented itself in Montréal, Québec, where Communauto operates. Communauto is the first and one of the largest carsharing companies in North America, with 1,000 cars and 20,000 members in 2010. A web-based travel survey was conducted in September, 2008, of its 14,500 members living in the Montréal area, at the same time as the 9th regional, large-scale Origin–Destination survey (5% sample) was being carried out. This process provided unique data to compare the travel behaviors of carsharing households and of typical households in the area. The comparison presented here is aimed at analyzing the socio-demographic characteristics and travel behaviors of carsharing users and their households.

This article is structured as follows. The basic carsharing concepts and the importance of Origin–Destination surveys in the Montréal area are presented first. Then, the survey methodology and the web-based tool that were developed to gather data from the carsharing members is briefly described, as well as on the process required to make the database of data usable for analysis. Key facts regarding the sample are also provided, relating to its statistical representativeness. The article continues with a comparison of the travel behaviors of carsharing members and similar individuals in typical households. Finally, our conclusions and suggestions for future research are presented.

BACKGROUND

Basic concepts regarding carsharing services and their role in Montréal are presented, along with some details on the way in which travel surveys are conducted in the area.

Carsharing Concepts

Carsharing is based on an old idea: sharing an expensive resource to allow many people to use it without anyone assuming the entire financial burden on his own. Although it is not a new idea, carsharing systems have only recently shown the
potential to increase their market share significantly and to play a role in urban areas. Today, carsharing companies provide cars on the basis of a web or phone request by managing a fleet of vehicles distributed in a number of parking lots, called stations. With their member key, users have direct access to any vehicle, at any time, if they have made a reservation in advance. This enables users to adapt their mobility choices to their particular needs, without the burden of the payback period inherent to car ownership.

This mode of transportation is dependent on the flexibility the car can provide and fills a gap left by other modes, such as public transit, the personal car, and the taxi (Britton and World Carshare Associates 1999; Jemelin and Louvet 2007; Millard-Ball et al. 2005). Carsharing offers many other advantages:

- Both long-term and short-term rental are available, on a regular or occasional use basis, and reservations are hour-based, which makes carsharing more flexible than conventional car rental;
- It is cheaper than taxi services, and;
- It creates a good environmental image and is one of the more innovative components of sustainable transportation schemes (Steininger, Vogl, and Zettl 1996; Goldman and Gorham 2006).

These features attract households that can afford to own a car, but don’t need one on a full-time basis (Communauto 2006).

A number of studies have been conducted for the estimation of the carsharing users potential market. These studies highlighted some influencing factors such as population characteristics and advertising issues (Jemelin and Louvet 2007; Heling, Saphores, and Samuelson 2009; Martens, Sierzchula, and Pasman 2011). In addition, some studies refer to the need to create a label to establish standards for carsharing service (Ohta et al. 2009; Clavel, Mariotto, and Enoch 2009). Other research addresses changes in transportation behaviors when a carsharing service is available (Shaheen 2001; Cervero et al. 2002; Chin and Lee 1998; Douma and Gaug 2009). Results are sometimes counterintuitive or divergent. For instance, Cervero et al. (2002) found that carsharing could actually increase the use of cars by attracting more users to car ownership (San Francisco area). Other authors believe otherwise, maintaining that users are abandoning car ownership to join the system, and hence contributing to a decrease in car ownership (Millard-Ball et al. 2005; Shaheen and Cohen 2008). Since many studies are based on stated behaviors and on an analysis of a sample related to a specific area, results may have to be considered with caution. Even though the effects of carsharing are easily 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 Montréal Area. Since 1970, nine surveys have been carried out, one about every five years, at a 5% sampling level. The survey questionnaire focuses on three main objects: household, people, and trips. These large-scale surveys, conducted by phone, allow detailed information to be gathered on every trip taken by people aged five years and older on one day in the fall. In
2008, the survey collected data on about 355,000 trips made by 156,000 people making up some 66,000 households.

At the same time, a web-based survey was conducted among the members of the Montréal carsharing company Communauto. This company, which was established in 1994, was the first of its kind in North America. Since then, it has grown to be one of the most important systems on the continent and is growing fast.

In order to provide unique comparative data on the travel behaviors of carsharing members, the questionnaire was developed based on the typical large-scale travel surveys regularly conducted in Montréal. This exercise had two main objectives:

- To prototype and test a web-based transposition of the current CATI-based questionnaire used for the regional, large-scale travel surveys; and
- To create a one-day trip diary for carsharing members, noting the attributes of their households and collecting information on the daily travel habits of the household members, all of which would be used for travel behavior comparison.

METHODOLOGY

In this section, further details on data collection and database processing are presented.

Data Collection

The survey focusing on Communauto members was conducted over the longer period of the regional, large-scale Origin–Destination (OD) survey. While the 9th regional OD survey conducted in 2008 lasted from September 2nd through December 19th, the survey of Communauto members was posted online from September 17th to November 30th of that year.

Communauto chose a web-based survey instead of the phone interview method used in the regional, large-scale survey. This decision was taken for two main reasons: limited resources for survey execution, and the familiarity of Communauto members with the Internet. According to the Communauto satisfaction survey of 2008, about 90% of Communauto members reserve their car using the Communauto web-based booking software. This choice of using a web tool to collect data impacts results interpretation, because the respondents may have greater difficulty understanding the trip concept, as they are not helped by an interviewer (Bayart 2009). Therefore, a smaller number of declared trips per day is anticipated, which means that we must be very careful in comparing this survey with the regional survey, and in the interpretation of the results.

The web questionnaire was developed with dedicated commercial survey software and had three main objectives: (1) to conform as much as possible to the regional OD survey; (2) to be as succinct as possible; and (3) to be as simple as possible.

Yet the tool had some limitations that complicated the development of the questionnaire and the anticipated quality of the responses, such as no loops within the questionnaire, no “back” button, no saving, and reusing of previously entered information. Sioui et al. (2009) described the survey process and tool. Still, the
A survey was conducted among the users and permitted relevant information to be gathered.

**Database Processing**

Figure 1 illustrates the six steps followed in this article, from the construction and validation of the datasets to the analysis and comparison of Communauto and Montréal households.

**Construction of the Communauto Member Database**

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

For this validation, we used the official membership database as of September, 2009. This database includes both former members (no longer members in the fall of 2008) and current members (who 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. Thus, the target population survey was conducted among the users and permitted relevant information to be gathered.

**Construction of the database of survey respondents**

Posted online from September 17th, 2008 to November 30th, 2008

- 1. Validation of responses
- 2. Imputation of missing and inconsistent values for the age and the postal code of the home location (from carsharing member database)
- 3. Assignment of the frequency of carsharing service use (from carsharing member database)

**Sample representativeness of carsharing members**

- 1. Age range
- 2. Frequency of carsharing service use
- 3. Space

**Selection of households used for the further comparison**

- 1. Households with at least one member between 20 and 54 years old
- 2. Households living in the municipal sectors with over 24 respondents

**Analysis of the frequency of carsharing service use**

for different types of households

- 1. Households: Car ownership, size of the household
- 2. People: Age, occupation, driver’s license
- 3. Trips: Mobility rate, transportation mode, purpose of the trip

**Comparison of carsharing and typical households**

- 1. Households: Car ownership, size of the household
- 2. People: Age, occupation, driver’s license
- 3. Trips: Mobility rate, transportation mode, purpose of the trip

Figure 1. Steps followed for the analysis of the web-based OD survey conducted among Communauto members. (Figure appears in color online.)
for the web-based survey conducted during the fall of 2008 is defined as all members living in the GMA who did not cancel their subscription before September 17th or who subscribed to Communauto before November 30th. For further analysis, the age of the members during the survey period is needed, and was derived from the birth date. A reference date was set for estimation: October 31st, 2008, which is in the midpoint of the online survey.

Overall, as shown in Figure 2, the target population includes 13,712 Communauto members. Members with no birth date were excluded, in order to simplify further treatment on representativeness.

Construction of the Database of Survey Respondents

First of all, two items of information are required for a sample unit to be kept for further analysis: (1) member ID and (2) home location (postal code). Normally, the web tool automatically registers the member ID, but some mistakes occurred and 85 questionnaires had no member ID. Also, some member IDs that had been automatically registered during the survey were not validated when compared with the Communauto member database. Figure 3 shows the methodology used to construct the database of survey respondents.

Concerning the home location question, if it has not been answered by a survey respondent or is absent from the Statistics Canada postal codes database, the Communauto member’s database entry is consulted to provide the information. In all other cases, it is considered that the information provided by the respondent...
during the survey takes precedence over the postal code in Communauto’s administrative dataset, which dates from September 2009.

Moreover, some respondents filled out the questionnaire more than once. For these units, we hypothesize that the latest attempt is the most relevant, since the member probably considered that their previous attempt was incomplete or incorrectly completed. This hypothesis could be validated using various tests on the collected information. Statistics on these multiple questionnaires show that most of the time the questionnaire fill out last is more complete than previous ones, that is, 82% of the multiple questionnaires completed on the same day and 58% of the multiple questionnaires completed on two different days.

SAMPLE ANALYSIS AND RESULTS

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

The representativeness of the survey respondents relative to that of 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 in terms of age (see Figure 4). The youngest members (16 to 19 years old) are over-represented, but few in number (3 questionnaires for 22 members). Also, a lower proportion of the oldest members (55 to 88 years old) filled out the questionnaire than members of the other age groups. These observations were expected for a web-based survey, because younger people are more accustomed to using the Internet than older people.

Considering that there are too few members younger than 20 and that the degree of participation of the respondents over 54 years old is too low, only respondents between 20 and 54 years old are used for our analysis.

Figure 4. Representativeness of survey respondents based on age range and carsharing service use representativeness. (Figure appears in color online.)
Carsharing Frequency of Use Representativeness

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

For Communauto households, a distinction has been made regarding the level of use of shared cars. In this study, it has been established that inactive Communauto members did not use the carsharing service during 2008 at all. Some members (limited users) used the carsharing service between 0 and 0.5 times per week, moderate users between 0.5 to 1.5 times per week, and frequent users more than 1.5 times per week.

This figure clearly shows that people who use the carsharing service more frequently participated to a greater degree in the survey, and that participation was in proportion to their use of the system. This was expected, since the link to the survey popped up every time a member went online to book a car. Nevertheless, many non-frequent users of the carsharing service also responded to the survey. This may be explained by the fact that the web-based travel survey was also promoted in the Communauto monthly letter. As a result, sample size is over 5% of Communauto members for every category. All questionnaires will be kept for further analysis.

Spatial Representativeness

Survey respondents are not equally distributed in the areas where the Communauto members live. Also, since there are very few Communauto members in some areas, and so not enough survey respondents, we made the decision to exclude areas with fewer than 25 respondents. Figure 5 shows the response rate in areas
where the sample is sufficient to conduct a relevant analysis. Sampling varies between 5.4% and 11.1% in these areas.

Response Rates

The data sample comprises 1,311 questionnaires, representing 1,311 households, 2,814 people, and 3,589 trips. Figure 6 presents response rates for various parts of the survey. These rates are almost all over 90%.

Owing to many open-box questions, some correction and verification was required. First, some answers were incorrectly written by survey respondents, but still understandable and possible to categorize. This was the case for departure times, possession of a driver’s license, and main occupation, for which simple validation and quality control ensured the establishment of accurate rates. It was also possible to verify some answers using simple cross-validation. This was the case for driver’s licenses, for which the age requirement is at least 16 years, and for the age of the respondent, based on a Communauto member’s database entry. Analysis of locations and departure times of trips is not included in this article, because these still have to be validated and geocoded.

Frequency of Carsharing Service Use and Household Characteristics

Regarding carsharing service use, sampled households are mostly made up as follows: (1) 26% are single people without a car; (2) 33% are two adults without a car; and (3) 11% are two adults and a child without a car. Because inactive and less active members are underrepresented in the sample (see Figure 4), a weight is applied to sampled households, which is proportional to the frequency of use of the service by Communauto members.

The charts in Figure 7 show that the inactivity of members increases with the number of adults, cars, and children in the household. Paradoxically, the intensity of carsharing use also increases with the number of children. In fact, it seems that
in non-motorized households, the presence of a child increases the use of the carsharing service.

**COMPARISON OF COMMUNAUTO MEMBERS AND THEIR HOUSEHOLDS WITH A TYPICAL POPULATION**

In this section, some figures and statistics are presented in order to provide a better understanding of the characteristics of households with at least one carsharing member, of the people living in these households, and the transportation modes they use. A comparison with the 2008 regional, large-scale Origin–Destination (OD) survey conducted in Montréal is made. For these analyses, we decided

**Figure 7.** Share of carsharing service use for different types of households. (Figure appears in color online.)
to compare households in which at least one person is a Communauto member (“Communauto household”, CH) with the OD survey households (“Montréal household”, MH) with similar characteristics, which are located in the same municipal sectors, and which have at least one member between 20 and 54 years old in their household.

**Households**

The collected sample comprises 1,311 households. Concerning household size, Communauto members seem to live more commonly in 2-person households (44% of CH compared to 33% of MH; see Figure 8), even though single people are represented in the Communauto and OD surveys in the same proportion.

Moreover, larger households (5 people or more) are more common in MH. Therefore, the mean household size is a bit larger for this group. CH car ownership is 0.13 cars/household, which is significantly less than that for MH, with 0.89 cars/household. Household car ownership is greater for all household sizes. This means that CH own fewer cars than the general population.
People

An OD survey also gathers information on the people living in the households surveyed (2,814 people in this study). Demographic composition comparison shows that CH contain more people between 20 and 39 years old than do MH (see Figure 9). Also, CH show higher proportions of preschool children than MH.

Figure 9 also compares CH and MH with respect to peoples’ occupations. There are more full-time workers and children under 5 years old in CH than in MH. Yet, at home, retired people (included in “Others”) and students are much less numerous. This information follows the trends shown in the demographic distribution. Children living in a CH are younger, with an average age of 6.5, compared to 8.3 for those living in MH.

Moreover, 85.1% of persons older than 15 in CH have a driver’s license, compared to 73.4% in MH.

Trips

According to the information gathered, some 27.9% of people in CH declared having made no trips on the day they were surveyed (12.8% in MH). The difference is great, but the current dataset does not allow us to correctly interpret this difference. Our study cannot specify whether the high non-mobility rate is attributable to the survey tool or to a lower number of trips made by people living in
carsharing households. Concerning the first option, Bayart (2009) also obtains a higher non-mobility rate, which the author partially explains by a lack of understanding of the trip concept on the part of the respondents and the respondent burden. The second option would imply that carsharing households have some socio-demographic characteristics involving less mobility, and that this high non-mobility rate could also explain their carsharing membership. So far, it cannot be concluded that one option better explains the high non-mobility rate of people in carsharing households than the other.

Further analysis will focus on the people who actually traveled. The web-based survey enabled us to gather information on 3,589 trips made by 1,675 people in 1,020 households. According to these data, people in CH make many fewer trips per day per person than in MH. This is because of the lower number of return trips home. At this point, we can suggest that some survey respondents neglected to declare their last trip, which would close the trip chain. In comparison, only 51% of Communauto members’ last trips were for the purpose of returning to

![Modal split of car use and trip rate comparison for single households.](image)

**Figure 10.** Modal split of car use and trip rate comparison for single households. (Figure appears in color online.)

their home location, compared to 94% in MH. In order to conduct a relevant comparison, trips with this purpose are removed and analyses are conducted on the other main trip purposes. Doing this makes the mobility rates similar.

First, single people without a car represent 26% of CH, and 68% of them made at least one trip during the day. It is possible to compare the modal share of car use and the purposes of trips made by members living in a single CH without a car to similar MH with no car or one car (see Figure 10).

Figure 10 shows some very interesting trends. First, people with the smallest modal share of car use are those without a motor vehicle. The lower frequency users of Communauto have a higher modal share of car use, and also a greater modal share of walk and bike. In this case, the modal split of car use increases with the frequency of use of the carsharing service, but never to the level of a similar person who owns a car. This suggests a more efficient use of the car and of alternative modes of transportation, in particular public transit. Between being a person with full access to a motor vehicle and being a high frequency

![Figure 11. Modal split of car use and trip rate comparison for 2-adult households without a child. (Figure appears in color online.)](image-url)
Communauto user with no car, there is a 25\% difference in the modal split of car use during a typical day of travel. Moreover, the difference increases with a decreasing frequency of use of carsharing services. Regarding trip rates, mobile persons in CH take as many trips per day as in MH, except for high frequency Communauto users, who have lower trip rates. Overall, the trip rate for work purposes of people in CH is similar to that of people in non-motorized MH. For the leisure and school purposes of trips, the trip rates of people in CH are similar to those of people in motorized MH.

A similar analysis was conducted for two-person households with varying degrees of car ownership and carsharing usage (see Figure 11). Again, a clear trend in the modal split of car use is observed in daily mobility with respect to car ownership. First, those living in households without a motor vehicle have the smallest modal share of car use. Then, modal split of car use increases with the typical frequency of use of the Communauto system, but never up to the level of a person living in a household with one or more cars. When comparing people who use the carsharing system frequently with those living in a MH owning one car, modal share of car use doubles, and it triples if the MH has two cars.

So, people living in a non-motorized single or two-adult household with a more than 1.5 times per week frequency of use of the carsharing service still have a modal share of car use that is at least 25\% smaller than that of other people in a similar MH (excluding return trips home). This confirms the significant impact of carsharing membership. Again, it suggests that the availability of one or two privately owned cars in a household is a determinant of the incentive to use the car more intensely and to make less frequent use of other available modes of transportation.

CONCLUSION

This article has presented a survey experience involving members of a carsharing enterprise in order to gather data on travel behaviors on a typical day. The data collected were used to conduct an analysis to compare households with carsharing members with those of typical residents. The article also provides a description of the methodology for data gathering, processing, and analysis. Key figures of the daily travel behaviors were compared with two sets of data: various types of carsharing users and typical people in the region.

Modal share was used as a first indicator. Results show that households without a motor vehicle engage the least in the modal split of car use. Moreover, modal share of car use increases with the frequency of carsharing service use. However, it shows that, regardless of the carsharing service use, modal split of car use never rises to the level observed for similar households owning one or more cars. Such results have been confirmed for various types of households. In the near future, the comparison of the behaviors of people in carsharing households will be enhanced using other travel indicators. The geocoding and the insertion of trip ends will be finalized, applying the tools and databases typically used for the geocoding of regional, large-scale survey data. This step will allow us to estimate travel distances by mode of transportation. Trip chaining behaviors will also be examined.
ACKNOWLEDGMENTS

The authors thank Communauto for making it possible to conduct a survey of their members and for their continuous support and R&D conducted at the École Polytechnique de Montréal. They also acknowledge the assistance of the technical committee of the regional travel surveys for providing prime access to parts of the latest Origin–Destination survey to allow us to conduct an up-to-date comparison of behaviors (with the help of Daniel Bergeron and the Metropolitain Transport Agency).

REFERENCES


How Carsharing Affects Travel Behavior


