

Modeling spatio-temporal diffusion of carsharing membership in Québec City



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ABSTRACT

During the last few years, car sharing has undergone significant growth, both in Canada and around the world. In this type of service, users share access to a fleet of vehicles, thereby giving them most of the advantages of automobile use, such as its temporal and spatial flexibility, without many of the constraints of ownership. This study analyzes the geographical and socio-economic factors that favour membership of a carsharing service in Québec City. We combined Cervero's and Kockelman's 5D model (density, diversity, design, distance to transit, and destination accessibility) with Hägerstrand's concept of innovation diffusion so as to analyze the evolution of potential car-sharing membership. Zero-inflated negative binomial (ZINB) regression was used to model the spatial diffusion of the number of car-sharing members in Québec City from 1996 (two years after its inauguration) to 2008 at the local scale, with an annual time step. Results indicate that the carsharing distribution did, indeed, follow Hägerstrand's innovation diffusion model and that, even though some of the 5D model significantly influenced membership, it was socio-economic factors (education, non-motorization, and family structure) that most greatly affected the membership rate in the service area. The model is used to assess and discuss market coverage potential in Québec City.

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1. Introduction

There have been numerous studies conducted on the consequences of developing cities around the automobile. The evolution of transportation methods in the Western world has converged toward what could be described as an automobile “monoculture” (Sperling and Gordon, 2009). Car-centered transportation has had all sorts of impacts, be they urbanistic, economic, social, or environmental. A common point in current discussions concerns the place of the car in urban environments. Despite the rise in popularity of alternative transportation methods, cars remain, in a society based on exchanges, the transportation method that best meets “an increasing need for transportation flexibility, both in terms of schedules and destinations” (TECSULT, 2006:9). Given the consequences of “everything for the car,” the need has arisen to develop “more individualized” public transportation methods for today's society, such as car sharing (Ascher, 2001). In other words, despite the evident disadvantages associated with it (Katzev, 2003) and

because of a well-established culture of moving around in individual cars, it has become difficult in the current context to compete with the automobile paradigm: “The car can be integrated into the complex structures of contemporary lifestyles like no other mode of transportation” (Nobis, 2007: 35). It is argued that car sharing allows users to combine the advantages of a car, such as its temporal and spatial flexibility, without many of the constraints of ownership. It is an alternative model of car ownership, use, and access (Britton, 1999), analogous to carpooling but without the disadvantages of schedule and route incompatibility.

While there are several definitions of carsharing, the Transportation Research Board recommends the following: “A membership program intended to offer an alternative to car ownership under which persons or entities that become members are permitted to use vehicles from a fleet on an hourly basis” (Millard-Ball et al., 2005: 2.2). In other words, members of a carsharing service pay for costs related to kilometres driven and time of usage, which gives them access, generally upon reservation, to cars available in a “self-serve” mode in predetermined parking lots. The subscription, reservation, and payment system, the type of organization, and means of operation all vary according to the company considered. But whatever the specific characteristics, the goal usually remains the same: to make car use more efficient, since owning

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a car, with the high ratio of fixed costs to marginal usage costs it entails, inevitably encourages its usage (Nobis, 2006). What is more, carsharing optimizes the usage time of cars, where, in normal circumstances (when owned by an individual or family), it is only used 2% of the time, as compared to 30–40% for shared cars (Scott et al., 2003).

Carsharing began in Zürich, Switzerland, in 1948. At the time, a group of citizens decided to share cars through the creation of a cooperative, *Sefage*. This neighbourhood effort, which cannot be considered a modern, car-sharing organization, ended in 1998 (Robert, 2005). Switzerland, the Netherlands, Germany, Denmark, France, Ireland, Italy, Scotland, and Sweden were, in the early 1990s, the main countries with carsharing companies (Shaheen et al., 1998). Since then, the service has grown considerably on the European continent as well as in North America, with 14 operators in Canada (39,664 members; 1667 vehicles) and 19 operators in the United States (279,174 members and 5838 vehicles) (Stillwater et al., 2009; Shaheen and Cohen, 2007; Shaheen et al., 2009). On a worldwide basis, we are seeing rapid growth and an increasing diversification of service (e.g. one-way rental, rental without reservation), such that, by October 2010, more than 1.25 million individuals were sharing over 31,660 cars (Shaheen, 2012).

The first North American organization to provide a regular service was *Auto-Com* in Québec City in 1994, years before *City CarShare* in San Francisco (Cervero et al., 2007). In 2000, *Auto-Com* became *Communauto*, which had, in 2011, more than 24,000 members in seven cities across the province of Québec (Québec City, Montréal, Sherbrooke, Gatineau, Laval, Longueuil, and Lévis), with more than 4000 members each in Québec City and Lévis (Fig. 1). The travel behaviour of Montreal users was studied (Habib et al., 2012; Sioui et al., 2012), but the deployment process of service in the urban space is still to be investigated.

Numerous researchers have looked at this growing phenomenon, particularly since the first pilot projects in the United States. However, research first began in Europe, in particular with Biau (1991), who described a self-serve car service in Montpellier, France, in the early 1970s. Shaheen et al. (1998) wrote up a history of carsharing around the world, highlighting the success of certain projects in Europe and the beginning of the phenomenon in North America. Studies on the impact of carsharing were conducted by Litman (2000) and Katzev (2003). They examined *Carsharing Portland*, the first company of its kind to be firmly established in the United States. In a report written in 1999, Shaheen (2004) used theories of social marketing and learning to explain the process underlying the people of San Francisco's acceptance of transportation innovation in the form of the carsharing service *CarLink*, which was setup under her supervision. Cervero (2003) and Cervero and Tsai (2004) examined the *City CarShare* program in California and observed

the effects of travel behaviour after one and two years of service. Robert (2005) drew up the history of *Communauto* in Québec City, while Lane (2005) analyzed the motivations of users of *PhillyCarShare* in Philadelphia and the impacts on their mobility. Shaheen et al. (2006) examined the increase in carsharing in North America and estimated its growth potential in large metropolitan regions at around 10% of people aged 21 and over. More recently, Shaheen et al. (2009) looked back at the last decade of carsharing in North America, identifying three phases in the development of North American organizations: market insertion, from 1994 to mid-2002; growth and diversification, from mid-2002 to 2007; and a larger-scale offer, from the end of 2007 until today. Carsharing continues to be of interest to researchers, in particular from the perspective of its impact on motorization (Cervero et al., 2007; Martin et al., 2010), the multimodal aspect of the phenomenon (Nobis, 2006, 2007), its effects on the environment (Alexandre, 2010; Firmkorn and Müller, 2011) and user behaviour (Jemelin and Louvet, 2007; Morency et al., 2012; Costain et al., 2012), or its potential in individual cities such as Shanghai (Wang et al., 2012).

The present article examines the geographical and socio-economic factors underlying the deployment of the carsharing service in Québec City so as to determine their relative weight using a statistical model. In keeping with Stillwater et al. (2009), we hypothesized that carsharing potential is linked to urban form, and limited to high-density neighbourhoods with good access to daily services and workplaces. We combined Cervero and Kockelman's (1997) 3D model – density, diversity, design – and Cervero et al.'s (2009) 5D model, whereby distance to transit and destination access are added and are used regularly to assess transportation demand potential, with Hägerstrand's (1967) concept of innovation diffusion. The goal of this study is to model the spatial diffusion of carsharing membership in Québec City from 1996 (two years after the service was launched) to 2008. The objective is not to understand the mobility rationale underlying a user's choice to join but, rather, to determine the built-environment characteristics and the neighbourhood socio-economic attributes that favoured carsharing membership (market coverage), while considering the phenomenon's endogenous evolution. It is important to note the difference between membership and usage: we did not measure the frequency or likelihood of service utilization, but only the simple fact of being an active member (paid annual subscription) or not. To our knowledge, this is the first time that analysis of the spatial diffusion of carsharing is carried out at the city scale, thanks, among other things, to the duration of the service in Québec City. Moreover, the model developed here integrates and compares the effects of a large range of urban and socio-economic characteristics. The modeling approach simultaneously considers the growth of the service area (control of excess zeros) and the increase in membership using ZIP (zero-inflated Poisson) and ZINB (zero-inflated negative binomial) regressions so as to estimate growth with a capacity constraint (number of eligible drivers) at a large scale (hexagonal grid cells with a 250 m radius).

The rest of the article is structured as follows: Section 2 comprises the conceptual framework and the research hypotheses; Section 3 expands on the membership data, the characterization of urban areas, and the analysis methods; Section 4 shows the regression results; Section 5 presents and discusses findings; and the conclusion discusses the implications of the empirical results and suggests avenues for future research.

2. Conceptual framework

The theoretical framework of this research is built on three principles: (1) at the local level, carsharing membership rates (market coverage) should normally be related to motorization,

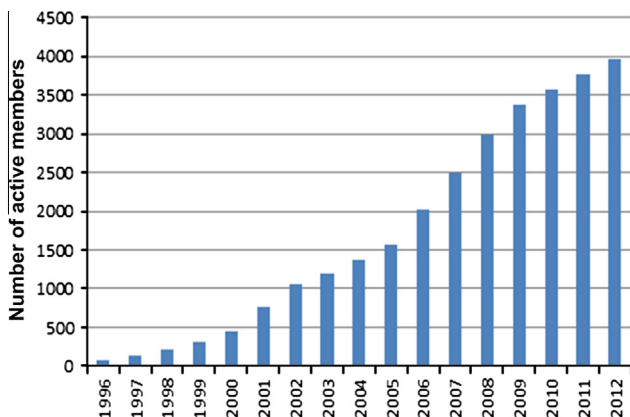


Fig. 1. Evolution in membership of Communauto in Québec City and Lévis (Source: Communauto, 2013).

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