



# Modelling users' behaviour of a carsharing program: Application of a joint hazard and zero inflated dynamic ordered probability model

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## ABSTRACT

This paper presents an econometric model for the behaviour of carsharing users. The econometric model is developed to jointly forecast membership duration, the decision to become an active member in a particular month, and the frequency of monthly usage of active members. The model is estimated using the membership directory and monthly transaction data of a carsharing program, 'Communauto Inc.', based in Montréal, Canada. The model shows a high degree of fit to the observed dataset and provides many behavioural details of carsharing users. The results are instructive to carsharing planners in devising efficient policies.

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## 1. Introduction

Carsharing is now recognized as an alternative mode of urban transportation. Given that it provides the flexibility of the private car and the reduced cost burden of public transit, it has high potential to reduce auto ownership as well as the total amount of auto trips made in urban areas (Meijkamp, 1998). In many cities around the world, carsharing is increasingly considered as an innovative mobility tool from the transportation policy point of view (Ohta et al., 2009). Although carsharing has been more recently introduced in North America than in Europe, it has already become a viable alternative mode to the private automobile in many North American cities. In the face of high energy costs and an increasing demand for energy efficiency and environmental responsibility, the popularity of carsharing programs is increasing in North America (Zhou and Kockelman, 2008). According to Shaheen et al. (2009), the history of carsharing in North America can be divided into three phases: initial market entry and experimentation phase (1994–2002); growth and market diversification phase (2002–2007); and commercial mainstream phase (2007–present). The upshot is that carsharing is now an established fact in North America. According to Stillwater et al. (2008) carsharing in North America is increasingly becoming a complementary good to high density travel, both in terms of its encouragement of comparably high vehicle occupancy as well as in locating/inducing a high density of built environment in urban areas.

The first North American carsharing program was launched in Québec in 1994 (by the company previously known as Auto-Com and currently known as 'Communauto Inc.'). The first program in the US was introduced later, in 1998, by the organization named 'Carsharing Portland' in Oregon (Katzev, 2003). Since then carsharing has spread across North America with increasing membership bases (Shaheen et al., 2009). Research on this mode of transportation is also expanding in many

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dimensions. However, until now, most of the research investigations have focused on the feasibility of carsharing as an alternative mode; on developing efficient carsharing programs; and on studying the impact of carsharing on urban transportation. Little is known about the behaviour of carsharing users. Although some investigations have been conducted on carsharing users' behaviour, they have been limited in terms of survey data analysis and theoretical investigation. Empirical investigations based on econometric theory are rare in the literature. However, with the increasing popularity of this mode of urban transportation, urban transportation planners should consider it within their transportation and land use analyses. Among common urban transportation modes (auto driver, auto passenger, car pooling, transit, non-motorized modes, etc.) carsharing is distinct in terms of membership requirements for using the mode. In this regard, it is understandable that carsharing users' behaviour would be distinct from auto or transit mode users' behaviour.

We need to understand carsharing users' behaviour before investigating its impact on urban transportation system. As such, it is important that we understand details about carsharing members' behaviour in terms of enrolment behaviour in the carsharing program as well as persistence of use of the service. A systematic investigation of carsharing users' behaviour will help urban transportation planners to better understand the characteristics and impact of this emerging urban transportation mode as well as to devise efficient carsharing programs for large urban areas.

In a bid to address this gap, this paper presents the results of an investigation of carsharing users' behaviour. The investigation uses a portion of the members' frequency of usage and enrolment information data from the first North American carsharing program, 'Communauto Inc', of Québec. For the purpose of investigating users' behaviour regarding the observed membership duration as well as monthly activity persistency, a dynamic joint econometric model is developed. The empirical model reveals many behavioural details regarding carsharing users' behaviour. In addition, it is shown that the developed model is suitable for use as a revenue forecasting tool for the carsharing program. The remainder of the paper is organized as follows: Section 2 presents the literature review of investigations of carsharing impact and user behaviour, (mainly in the North American context). Section 3 presents the econometric formulation of the conceptual modelling framework. Section 4 presents a description of the data source for the investigation. Section 5 discusses the empirical model of carsharing user membership duration and activity persistency. Section 6 concludes the paper by summarizing important findings and identifying direction for future research.

## 2. Literature review

Early studies on carsharing in North America have focused primarily on the feasibility of carsharing programs, the history of the development of carsharing, and the impact of carsharing on auto ownership and vehicle usage. One of the first studies recorded on carsharing, authored by [Walb and Loudon \(1986\)](#), focuses on a short-term auto rental project and its influence in terms of reducing auto ownership and increasing transit usage in San Francisco. The study evaluates the successes and failures of the project in terms of attracting users while failing to meet transportation and societal objectives, as well as the effects on urban mobility. The study presents a data analysis of rental and financial records of the project and membership survey results in order to evaluate viability of carsharing in San Francisco. [Doherty et al. \(1987\)](#) present a similar study testing the concept of carsharing—more rightly a combination of carsharing and carpooling—in the US. Their study stems from a work-based shared vehicle concept and focuses on cost and utilization rates of such a program for successful implementation. [Steininger et al. \(1996\)](#) present a retrospective overview of the successes and failures of a carsharing program in Europe. They also report a comparative analysis of the impact of carsharing on user trip structure and mode choice. Their comparative data analysis is based on controlled experiments of voluntary new members of a carsharing program. The study concludes that understanding user behaviour is critical to any effort to quantify the impact of a carsharing program. [Wegner and Shaheen \(1998\)](#) point out that the success of any carsharing program requires that the carsharing service comply with user behaviours.

[Shaheen \(1999\)](#) investigates the impact of information and communication technology in making carsharing popular in US cities and influencing user behaviour. [Shaheen et al. \(1999\)](#) present a systematic investigation of commuters' attitudes towards a carsharing concept over time. Their investigation focuses on operational understanding, participation profiles, and economic viability. [Shaheen and Wright \(2001\)](#) present the findings of a pilot study on a commuter-based carsharing program. They find that carsharing can be a viable complementary mode to transit and feeder shuttles. [Katzev \(2003\)](#) investigates carsharing user behaviour based on a survey conducted among carsharing users. He finds that the occasional need for a car may motivate some people to join carsharing programs and thereby increase auto travel. He also finds that the duration of membership as well as the presence of a carsharing service network in one's neighbourhood of residence has profound impacts on user activity persistency. [Rodier and Shaheen \(2004\)](#) present a case study of the impact of carsharing on urban travel demand in Sacramento, California. The simulation-based study reveals that an efficient carsharing program can contribute to moderate reductions in auto ownership and traffic-related emissions in urban regions.

[Vance et al. \(2005\)](#) present an evaluation of the performance and impact of a carsharing program in Seattle. Their study reveals that the majority of carsharing users are transit users and they suggest that a detailed study is necessary in order to understand the behaviour of carsharing users. [Fukuda et al. \(2005\)](#) investigate the potential of carsharing as an alternative mode based on stated preference survey conducted in Bangkok, Thailand. [Lane \(2005\)](#) reports that in North America, carsharing users are more concerned with personal utility than social or environmental benefit, and are motivated more by convenience and less by affordability. [Shaheen and Rodier \(2005\)](#) assert that an effective carsharing program can increase transit

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