Accident Analysis and Prevention 70 (2014) 140–147

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Modelling crash propensity of carshare members

Vinayak Dixit*, Taha Hossein Rashidi[1]

School of Civil and Environmental Engineering, University of New South Wales, UNSW, Gate 11, Botany Street, H20 CVEN, L1, Room 113, Sydney, NSW 2031, Australia

ARTICLE INFO

Article history:
Received 1 May 2013
Received in revised form 1 March 2014
Accepted 11 March 2014
Available online 12 April 2014

Keywords:
Carshare
Safety
Censored biprobit
Quasi-induced exposure

ABSTRACT

Carshare systems are considered a promising solution for sustainable development of cities. To promote carsharing it is imperative to make them cost effective, which includes reduction in costs associated to crashes and insurance. To achieve this goal, it is important to characterize carshare users involved in crashes and understand factors that can explain at-fault and not-at fault drivers. This study utilizes data from GoGet carshare users in Sydney, Australia. Based on this study it was found that carshare users who utilize cars less frequently, own one or more cars, have less number of accidents in the past ten years, have chosen a higher insurance excess and have had a license for a longer period of time are less likely to be involved in a crash. However, if a crash occurs, carshare users not needing a car on the weekend, driving less than 1000 km in the last year, rarely using a car and having an Australian license increases the likelihood to be at-fault. Since the dataset contained information about all members as well as not-at-fault drivers, it provided a unique opportunity to explore some aspects of quasi-induced exposure. The results indicate systematic differences in the distribution between the not-at-fault drivers and the carshare members based on the kilometres driven last year, main mode of travel, car ownership status and how often the car is needed. Finally, based on this study it is recommended that creating an incentive structure based on training and experience (based on kilometres driven), possibly tagged to the insurance excess could improve safety, and reduce costs associated to crashes for carshare systems.

1. Introduction

Since the 90s innovators, industries, cities and decision makers (Prettenthaler and Steininger, 1999) have been working to materialize the concept of car sharing in large cities of Australia, Switzerland and Germany, as well as Sweden, the Netherlands, Canada and the United States on a smaller scale (Mont, 2004; Steininger et al., 1996). An efficiently designed carsharing system would provide an ideal alternative to private vehicle ownership, car leasing and renting a car, by providing users the ability to have flexibility and travel large distances while maintaining their predominant choice of mode as public transit, walking, bicycling, taxis etc. Shaheen et al. (2009) provided a comprehensive review of the evolution of carsharing, and its value towards development of a sustainable transport system. Several other studies also discussed the sustainability benefits of carsharing (Fellow and Pitfield, 2000; Steininger et al., 1996; Cervero et al., 2007; Firnkorn and Muller, 2011).

Recently there have been studies (Habib et al., 2012; Constain et al., 2012) that have investigated choice behaviour of carsharing users regarding: membership duration, the decision to be an active member, and the frequency of monthly usage. It was found that usage costs are the biggest determinants of the usage of carshare systems. Members of a carshare system do not deal with fuel or insurance costs but pay by use. Therefore fuel and insurance costs are embedded in the usage costs, which depend on the time period of use and/or kilometres travelled. To ensure the success of carsharing, it is imperative to lower overall costs, which also includes reducing insurance costs. Therefore, it is critical to understand crash risks of various individuals participating in a carshare scheme.

To the best of the authors' knowledge, after an extensive review of literature, this study is the first to study crash risk of carshare users. This research studies the discrete outcomes of crashing and being at-fault. Previous studies have assessed crash characteristics using discrete outcome models, such as the binary logit (Haque et al., 2009), ordered probit (Pai and Saleh, 2008), multinomial logit (Shankar and Mannering, 1996), nested logit (Savolainen and Mannering, 2007), and mixed logit (De Lapparent, 2006). Zhang (2010) identifies the assumptions and strengths of these models.

* Corresponding author. Tel.: +61 2 9385 5381; fax: +61 2 9385 6139.
E-mail addresses: v.dixit@unsw.edu.au (V. Dixit), rashidi@unsw.edu.au (T.H. Rashidi).
[1] Tel.: +61 2 9385 5063; fax: +61 2 9385 6139.

http://dx.doi.org/10.1016/j.aap.2014.03.005
0001-4575/

Unlike most crash datasets in which only information of people involved in accidents are present, a unique aspect of the dataset used in this study is that it contains information regarding all members, including those who are not involved in crashes as well as those involved in crashes and identified as at-fault or not-at-fault drivers. This also provides an opportunity to study attributes of not-at-fault drivers which play an important role in crash studies utilizing quasi-induced exposure methods.

Characterizing the cause of crashes relies heavily on normalizing occurrences of crashes based on risk exposure. Kilometres driven by a particular driver is widely accepted as a representation of this exposure. Unfortunately, crash databases do not typically contain this information making estimation and approximation of the exposure rate a challenging issue. To address this issue the concept of *induced exposure* was developed by Thorpe (1967). Induced exposure was found to have typical issues associated with assigning responsibility for crash causation, which led to the development of *quasi-induced exposure* (Haight, 1970).

Quasi-induced exposure method is based on the premise that not-at-fault drivers are a random sample of the driving population, which is utilized to characterize the at-fault drivers by studying the involvement ratio, i.e. the ratio of at-fault drivers to not-at-fault drivers for a certain group. An important advantage of this method is that it does not require other exogenous measures of risk exposure such as vehicle kilometres travelled, traffic volumes at a location etc., and can rely solely on the crash database. Due to these advantages researchers and practitioners (Yan et al., 2005; Chandraratna and Stamatiadis, 2009; Jiang and Lyles, 2010; Mendez and Izquierdo, 2010; Jiang et al., 2011, 2012) have begun to heavily rely on quasi-induced exposure method to characterize crash risks. Due to the increasing popularity of this method, it has become imperative to study the validity of the underlying assumptions, such as that of not-at-fault drivers being a random sample of the driving population, which also requires that crash responsibilities are correctly assigned. Jiang et al. (2011) used the U.S. National Household Survey to validate the Quasi Induced exposure method, and found the results to be promising.

Studies that have undertaken to evaluate quasi-induced exposure method can be categorized into two groups. The first type of these studies have focussed on biases associated to police officer's judgement in assigning fault to drivers during a crash. These biases in judgements can result in violation of the assumption of quasi-induced exposure regarding not-at-fault drivers being a random sample of all drivers. DeYoung et al. (1997) identified "negative halo effect", where in an investigating officer might assign fault to drivers' with suspended/revoked license, alcohol/drug use or based on other negative perceptions about the driver, despite not being objectively responsible for the crash. Kirk and Stamatiadis (2001) as well as Lenguerrand et al. (2008) found such biases in the crash data set. Rather than using the police assigned crash responsibility, the studies used exogenous methods to identify crash responsibility. Chandraratna and Stamatiadis (2009) when analysing multivehicle crashes found evidence of "negative halo effects" biasing the representation of not-at-fault drivers. Recently Jiang et al. (2012) found that hit-and run, gender, age, injury severity, and alcohol and illegal drug use significantly impact investigating officers' decision making.

The second type of studies can be characterized as those which compare quasi-induced exposure with traditionally used exposure metrics such as vehicle miles travelled or traffic volumes based on time of day or other disaggregate characteristics based on environmental, vehicle, roadway or driver characteristics. Lighthizer (1989), in one of the earliest attempts, compared key variables regarding crashes using the quasi-induced exposure method using the Michigan crash data. The study found the assumptions of the quasi-induced exposure method were met. Kirk and Stamatiadis (2001) were also able to qualitatively show the validity of the quasi-induced approach using the Kentucky crash database. On the contrary, there have been several studies that have found not-at-fault drivers to have significant under representation of vehicles with new technologies (Evans, 2004) and drivers belonging to younger age groups (Kahane and Hertz, 1998) that have higher accident avoidance capabilities. Drivers having higher speed have also been found to have a higher representation in not-at-fault drivers (Mendez and Izquierdo, 2010), mainly due to higher number of accident prone interactions (Navon, 2003) and reduced ability to avoid crashes. Jiang and Lyles (2007) also found that differentials in average speed between vehicle types and road users can affect involvement ratio while studying quasi-induced exposure.

In this respect, researchers (Stamatiadis and Deaco, 1997; Jiang and Lyles, 2007; Chin and Haque, 2010; Haque et al., 2012) have suggested the use of 'clean' dataset when utilizing quasi-induced exposure methods. As highlighted by Haque et al. (2012).

> "*Since induced exposure estimation relies on the fault of crash involvement, biased cases of fault assignment need to be removed.*"

This new 'clean' dataset is then compared with the entire dataset to determine whether the cleaning process resulted in any systematic biases, before being used in studying crash likelihood.

As identified by Chandraratna and Stamatiadis (2009), for the quasi-induced exposure method, the assumption of randomness of the not-at-fault driver sample is critical. They state:

> "*In statistical terms, a simple random sample is a set of drivers that have been selected from the driver population in such a way that every driver had an equal opportunity to be involved in a crash without being the at-fault driver. In other words, since the driver at-fault does not intentionally select a driver to strike, it can be reasonably assumed that each driver has an equal chance to be included in the not-at-fault driver sample.*"

Therefore, under this assumption of randomness, carshare members involved in a crash and not-at-fault should be a random sample of the carshare members. Since every member had an equal opportunity to be involved in a crash and be not-at-fault. However, if there is a non-linear relationship between certain driver, carsharing or exposure characteristics this might not hold true. The unique GoGet dataset contains information about the members as well as drivers involved in crashes but were not-at-fault, therefore providing a unique opportunity to evaluate this assumption associated to quasi-induced exposure.

The study also characterizes carshare users who have the propensity to be involved in a crash as well as be at-fault. This study utilizes member and crash database from the Sydney GoGet carshare users to evaluate the quasi-induced exposure method. The next section describes the data used for the analysis.

2. Data

This analysis utilizes GoGet member crash data in Sydney, New South Wales (NSW), Australia. The purpose of this study is to evaluate factors that affect the risk propensity of at-fault and not-at-fault drivers. The data was collected during the period from August 2010 to July 2012. GoGet have about 1000 vehicles located at strategic carshare locations around Sydney. The responsibility of the crash was assigned by the insurance company based on vehicle crash characteristics. The insurance company has no information about the personal details of the individual members involved in the crash. During the period of study the data included a total of 25,120 members, of which 161 were at-fault crashes, and 106 were not-at-fault crashes. This is shown in Table 1. The database included