Transportation Research Part D 34 (2015) 195–207

Contents lists available at ScienceDirect

Transportation Research Part D

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

Vehicle purchasing behaviors comparison in two-stage choice perspective before and after eco-car promotion policy in Japan

Gang Xu [a,*], Tomio Miwa [b], Takayuki Morikawa [a], Toshiyuki Yamamoto [b]

[a] Graduate School of Environmental Studies, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
[b] EcoTopia Science Institute, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

ARTICLE INFO

Keywords:
Vehicle type choice
Consideration set
Conjunctive screening rule
MCMC
Hierarchical Bayes

ABSTRACT

This paper compares the vehicle purchasing behaviors in Japan between before and after the eco-car (environmental friendly vehicle) promotion policy implemented. Consumer behaviors are modeled as a two-stage decision process: a consideration set formation stage and a choice-making stage. In the first stage, all available vehicle types are included in the choice set, and consumers are assumed to apply a conjunctive screening rule to construct consideration sets. In the second stage, consumers only evaluate the vehicles in the consideration set and choose the one with maximum utility. The applied Hierarchical Bayes model can avoid the issue of an indifferentiable and irregular likelihood surface caused by thresholds and discontinuities, and the data augmentation and Markov-Chain Monte Carlo estimation methods make it possible to estimate two stages simultaneously using only the information about the consumers' actual choices. The estimations indicate that the change of consumer behavior during the formation of consideration sets after the policy implemented: more people preferred compact and hybrid vehicles because of their better fuel efficiency and more competitive prices under the tax reduction policy. The results show, however, that most of consumers who purchase hybrid vehicles after the policy implemented are only including hybrid vehicles in their consideration sets, and oil price and vehicle price still play important roles in the choice-making stage for these who consider both gasoline and hybrid vehicles.

Introduction

The automobile industry has noticed the gradually increasing public concern about high energy prices and climate change. Therefore, the industry is developing cars that are environmentally friendly and fuel efficient, such as hybrid vehicles. Hybrid vehicles are difficult to promote, however, mainly because they are more expensive than traditional cars. Therefore, governments have implemented various hybrid vehicle promotion policies, such as tax reductions or monetary incentives, in order to increase the sales of hybrid vehicles. In 2009, the Japanese government introduced an eco-car promotion policy as a part of FY 2009 Tax Reform legislation (MOF, 2009) to stimulate sales of not only alternative-fuel vehicles, but also conventional vehicles that are fuel-efficient and have low emissions. The vehicles covered by the tax reduction policy are called eco-cars. This policy included tax reductions and monetary subsidies. The tax reduction policy was related to two taxes in Japan: the automobile acquisition tax and the automobile weight tax. The automobile acquisition tax is imposed at

* Corresponding author. Tel.: +81 52 789 3729; fax: +81 52 789 5728.
E-mail address: ttr169@gmail.com (G. Xu).

http://dx.doi.org/10.1016/j.trd.2014.11.001
1361-9209/

the time of purchase, while the automobile weight tax is imposed during the first mandatory inspection that generally is conducted within 3 years of the vehicle's purchase date and once every 2 years thereafter. Tax reductions were set at three levels: 50%, 75%, and 100%. The tax reduction level for a particular vehicle was determined by the vehicle's emissions levels. The more eco-friendly the vehicle was, the higher the tax reduction level. It should be noted that the 100% tax reduction level was applied to all alternative-fuel vehicles (AFVs), including hybrid vehicles and electric vehicles (EV). The monetary subsidy also was provided according to the vehicle's emissions levels. For qualified vehicles, the subsidy for a Kei-car, a small passenger car in Japan, was 70,000 yen. Other qualified passenger vehicles received 100,000 yen. All AFVs qualified for the subsidies. The basic price of a Toyota Prius, a famous hybrid vehicle, was 2.32 million yen and the two taxes for this car totaled 121,900 yen. Under the tax reduction policy, the car qualified for a 100,000 yen subsidy. Therefore a consumer purchasing a Toyota Prius could save 221,900 yen, which was equivalent to a 10% discount. This policy came into effect in April 2009. The monetary subsidy concluded at the end of March 2010, the automobile acquisition tax will conclude at the end of March 2017, and the automobile weight tax will conclude at the end of April 2017.

Giblin and McNabola (2009) analyzed the influence of a carbon-based tax system introduced by the Irish government on July 1, 2008, on new vehicles purchases and predicted the effect that these vehicles would have on CO_2 emissions. The Irish government changed the basis of the vehicle registration tax and annual motor tax rates in July 2008 from engine size to emissions performance in order to lower vehicle emissions. Rogan et al. (2011) assessed the impact of this new policy on car purchases. Zimmermannova (2012) analyzed the impact of the car registration fee on the structure of the passenger car fleet in the Czech Republic. This new economic instrument was introduced on January 1, 2009, and is based on vehicle emissions parameters.

The key aim of this study is comparing the vehicle purchasing behaviors in two periods, before and after the Eco-car promotion policy implemented in Japan. The vehicle purchasing data was obtained from nationwide vehicle ownership and usage surveys in 2009, 2011 and 2012, and divided into two groups: before the tax reduction policy was implemented and after it was implemented. More than two hundred vehicle types manufactured by Japanese automobile companies were included in the decision-maker's choice sets. Decision makers did not directly evaluate these vehicles, but eliminated vehicle types that they would not consider buying, and then chose one of the remaining vehicle types. In this paper, the two-stage decision process is modeled using the Hierarchical Bayes model (Gilbride and Allenby, 2004). The estimation results of the two data groups reveals not only how consumers evaluated vehicles but also what vehicles they would considered in purchasing.

In Section 'Literature review' of this paper, we review the literature on vehicle purchases and two-stage choice models. In Section 'Methodology', we present the data used in this research. In Section 'Data', we discuss in detail the parameters, modified screening rules, and estimation results. In Section 'Model specifications and estimation results', we present our conclusions.

Literature review

Most published studies of vehicle type choice have examined disaggregate choice models, such as multinomial logit (MNL) and nested log it (NL) models. Lave and Train (1979) developed an MNL model for estimating the vehicle type choices of 541 new-car buyers using a choice set containing 10 vehicle types. Manski and Sherman (1980) also developed a MNL model to estimate the vehicle possession choices of 1200 single-vehicle or two-vehicle households in the U.S. In their research, each household's choice set included their choice plus 25 alternatives randomly selected from 600 vehicle types. Mannering and Winston (1985) also used an MNL model to estimate household vehicle ownership choices in the U.S. The sample size was 3842 and the choice set included their choice plus nine alternatives randomly selected from 2000 vehicle types. Kitamura et al. (2001) used an MNL model and data from 1898 households in the South Coast metropolitan area (Los Angeles) in 1993 to analyze owned vehicle types; their choice set contained six vehicle types. Baltas and Saridakis (2013) used an MNL model to investigate the impact of behavioral and psychographic consumer characteristics on car preferences. They divided the vehicles into twelve categories based on vehicle size. Hocherman et al. (1983) developed an NL model to estimate the vehicle purchase behaviors of 800 households in Israel. In their NL model, the upper level were buying a first car or replacing an existing car and the lower level comprised the choice plus nineteen randomly selected alternatives from among 950 vehicle types. Berkovec and Rust (1985) developed an NL model of vehicle type choices, where the upper level had three vehicle age groups and the lower level five vehicle classes. The data was a nationwide U.S. sample of 237 single-vehicle households in 1976. Mannering et al. (2002) developed an NL model of vehicle type choice based on data from a survey of 654 U.S. households that had bought a new vehicle between 1993 and 1995. The upper level had two vehicle acquisition types—cash and no-cash—and the lower level comprised the choice plus nine alternatives randomly selected from 175 vehicle types.

The literature describes two kinds of vehicle type choice models: the vehicle purchase model when the chosen vehicle type is a new purchase (Lave and Train, 1979; Hocherman et al., 1983; Mannering et al. (2002)), and the owned vehicle model when the vehicle is already owned (Manski and Sherman, 1980; Mannering and Winston, 1985; Berkovec and Rust, 1985; Kitamura et al., 2001). The vehicle types in the choice set have been either categorized by functions and size (Lave and Train, 1979; Berkovec and Rust, 1985; Kitamura et al., 2001) or randomly selected from a large set (Manski and Sherman, 1980; Mannering and Winston, 1985; Hocherman et al., 1983; Berkovec and Rust, 1985; Mannering et al.,