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Modeling heterogeneous vehicle ownership in China: A case study based on the Chinese national survey

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ABSTRACT

Understanding the heterogeneity of vehicle ownership decisions in China is vital to accurately estimating the rate of vehicle ownership in its various provinces. In this study, we employ a latent class model to investigate the heterogeneity of vehicle ownership behavior, based on the China Household Finance Survey (CHFS) data. The results show that the households within the CHFS data can be categorized into two classes, and that households within each class rank the importance of socioeconomic variables in significantly different ways. For instance, with regards to deciding to own a vehicle, the households in Class 1 (the income-based class) rank household income as the most important factor, while the households in Class 2 (the comprehensive considerations class) rank household income, household status, and household size as being almost equally important. Further, the model coefficients also reveal the evolution of vehicle ownership in the near future, and how changes in macroeconomic variables may influence household vehicle ownership decisions. In application, the results can be used to assist policy makers in designing policies that control excessively high levels of vehicle ownership; they can also be used to help auto manufacturers pinpoint specific vehicle models to be sold in different regions of China, so as to drive the highest possible profits.

1. Introduction

Since 2006, there has been a substantial boom in China for automobiles, with the private vehicle stock increasing from 43.39 million to 108.50 million (NBS, 2014); in fact, China's vehicle sales market has, since 2009, outpaced that of the United States, and now stands as the largest vehicle sales market worldwide (Tang, 2009). However, vehicle ownership in China remains at 100 per 1000 people, which is a figure much lower than those seen in the United States (800), Europe (600), and Japan (450) (Huo and Wang, 2012). At the same time, vehicle ownership in various provinces of China are quite heterogeneous: As shown in Fig. 1, while vehicle ownership in Beijing in 2011 was 196 per 1000 people, that number was 60 in Shanghai, 117 in Zhejiang, 37 in Heilongjiang, and 59 in Sichuan. This regional heterogeneity of vehicle ownership makes it difficult for auto manufacturers to predict vehicle market trends, and therefore to propose new vehicle models to meet consumer demand. More importantly, the Chinese government has undertaken research whose results point to the viability of instituting a high vehicle purchase tax, a plate lottery, or other policies, all in the name of reducing automobile dependence, promoting public transit use, and reducing air pollution associated with transportation emissions (Chen and Zhao, 2013; Yang et al., 2014; Hao et al., 2015). Understanding the heterogeneous nature of vehicle ownership has emerged as a major priority for policy makers and auto manufacturers.

Much of the empirical work on vehicle ownership dates back to the 1970s and 1980s (Button, 1974; Tanner, 1978; Button et al., 1980). Since then, many approaches have been taken to investigate vehicle ownership. In particular, Bhat and Pulugurta (1998) compare two vehicle ownership modeling approaches, based on three US regional datasets and a Dutch national dataset; in that study, socioeconomic variables and residential attributes are set as independent variables. A comparison of ordered-response and unordered-response models concludes that vehicle ownership modeling should use an unordered-response class of models. Thereafter, the unordered-response class of models is mainly applied to the analysis of vehicle ownership, as in Bjorner (1999); Dissanayake and Morikawa (2002); Giuliano and Dargay (2006), and Whelan (2007).

Research on vehicle ownership models has shown that many factors impact vehicle ownership decisions at the disaggregate level. Among

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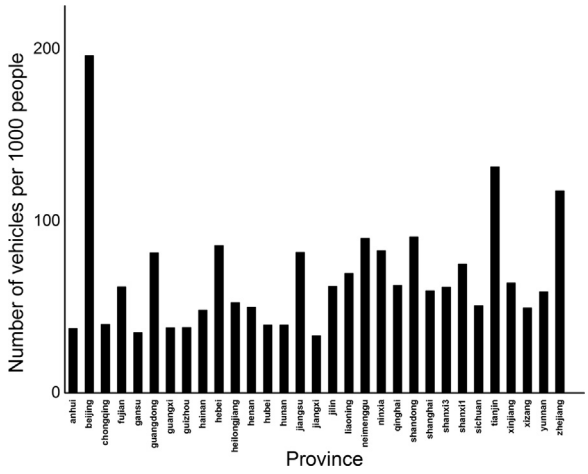

Fig. 1. Chinese province vehicle ownership.

the findings of these studies, socioeconomic factors, land use density, and macroeconomic variables are identified as the most significant factors to affect vehicle ownership behavior. The impact of income on vehicle ownership has been studied by Dargay (2001) and Dargay et al. (2007), each of whom examine the extent of asymmetry in the relationship between income and vehicle ownership. Other factors, such as household structure, land use, and accessibility, have also been recently studied. For example, Potoglou and Kanaroglou (2008) study vehicle ownership in Hamilton, Canada; they examine the influence of household structure, socioeconomic attributes, land use, and residential accessibility on vehicle ownership. Their findings are: (1) Permanent income has a stronger and more significant effect on the probability of household car ownership than current income; (2) Income elasticity differs by previous car ownership status; and (3) To reduce automobile dependence, planners and policy makers should consider strategies to improve transit services, permit mixed and diverse land use, and reduce home-to-work commute distance. Brownstone and Fang (2010) study the effects of socioeconomic characteristics, household structure, and residential variables on vehicle ownership, and they conclude that an increase in residential density has a negligible effect on car choice and use.

The research on vehicle ownership models reveals heterogeneous vehicle ownership behavior across different countries. For example, Whelan (2007) uses a British vehicle ownership model and finds that income and demographic structure each has a considerable impact on the number of cars owned. Ritter and Vance (2013) model vehicle ownership in Germany, using household size, the share of household members, income, gasoline price, and commute distance as determinants of vehicle ownership. Nolan (2010) investigates a vehicle ownership model by using Irish longitudinal data from the 1995–2001 period; that study mainly focuses on the impact of household income, previous auto ownership, land use, and life cycles on vehicle ownership. The findings of these studies indicate that residents in one country often exhibit behaviors different from those seen elsewhere. For instance, research in Canada (Potoglou and Kanaroglou, 2008) indicates that household size, household structure, education level, income, and transit accessibility each impacts vehicle ownership, while research in Germany (Ritter and Vance, 2013) concludes that besides these factors, gasoline price also has a significant influence on vehicle ownership. Additionally, research in the United Kingdom (Dargay and Hanly, 2007; Clark, 2009) and Spain (Matas et al., 2009) indicate heterogeneity in vehicle ownership behavior.

Research on vehicle ownership in China mainly uses aggregate modeling approaches to predict future vehicle ownership. For instance, Hao et al. (2011) and Huo and Wang (2012) model Chinese vehicle ownership and predict that the Chinese vehicle ownership through 2050 will range from 400 to 450 per 1,000 people. Li et al. (2010) study various dimensions of urban life on car ownership in 36 Chinese megacities. Hao et al. (2015) state that in 2050, Chinese vehicle ownership will be 347 and 397 per 1000 people, under "business-as-usual" and alternative scenarios, respectively; additionally, that study investigates energy consumption and greenhouse gas emissions associated with vehicle ownership. These studies point to future trends in vehicle ownership in China. However, owing to data limitations and unobserved contextual factors, very few studies have been undertaken on the determinants of vehicle ownership at the individual or household level, or on the heterogeneity of vehicle ownership in different regions of China.

The current research documents the development and analysis of heterogeneous household vehicle ownership in China, by making use of a latent class model (LCM). An LCM simultaneously estimates a class-specific vehicle ownership model and a class membership model. The first model specifies the probability of a household choosing to own a vehicle in the case of belonging to a specific class, while the second model estimates the probability of one household belonging to a particular class. By analyzing the coefficients of the class-specific vehicle ownership model and the class membership model, it is possible to explore heterogeneous vehicle ownership behavior. The China Household Finance Survey (CHFS) by the Southwestern University of Finance and Economics and the People's Bank of China, is used to analyze vehicle ownership decisions in China (Gan et al., 2013). The data cover 320 neighborhood committees (*Juweihui* in urban areas or *Cunweihui* in suburban areas) and 80 counties across 25 Chinese provinces (excluding Hong Kong, Macao, and the provinces of Inner Mongolia, Hainan, Tibet, Ningxia, and Xinjiang). Fig. 2 shows the coverage of the CHFS dataset (the "null" label shows the provinces that are not included in the CHFS data). It is noteworthy that the data cover all the provinces in eastern and central China. The results of the LCM show that the households within the CHFS data can be categorized into two classes: The households in Class 1 (the income-based class) rank household income as the most important factor, while the households in Class 2 (the comprehensive considerations class) rank household income, household status, and household size as being almost equally important. Further sensitive analysis shows how this research outcome can help government policy makes and auto manufactures.

Based on the discussion above, this research contributes to the literature in the following ways.

- This study is the first to cover as many as 8438 households in 25 provinces across China. The findings of this research can be

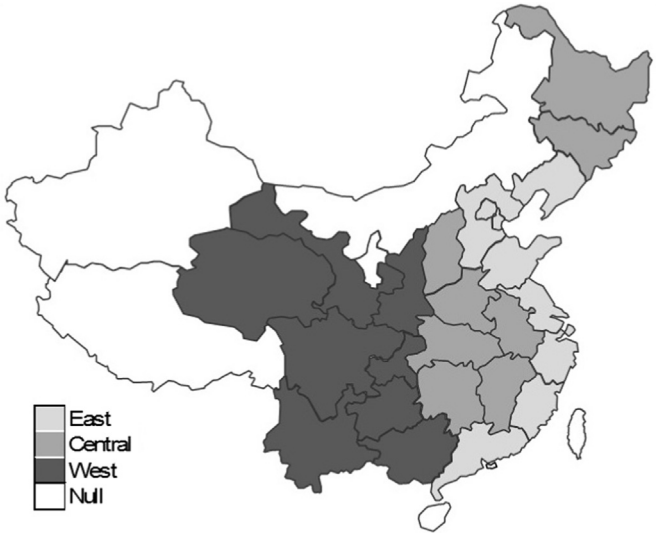

Fig. 2. CHFS data coverage.