Transportation Research Part A 46 (2012) 696–706

Contents lists available at SciVerse ScienceDirect

Transportation Research Part A

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

The asymmetric income effect on household vehicle ownership in Taiwan: A threshold cointegration approach

Rong-Chang Jou [a], Wen-Hsiu Huang [b,*], Yuan-Chan Wu [a], Ming-Che Chao [a]

[a] Department of Civil Engineering, National Chi Nan University, No. 1, University Rd., Puli, Nantou County 54561, Taiwan
[b] Department of Public Finance, Ling Tung University, No. 1, Lin Tung Rd., Taichung 40852, Taiwan

ARTICLE INFO

Article history:
Received 6 May 2011
Received in revised form 7 December 2011
Accepted 5 January 2012

Keywords:
Household vehicle ownership
Asymmetric threshold cointegration test
Asymmetric error correction model

ABSTRACT

This paper uses the asymmetric threshold cointegration test to examine the asymmetric relationship between household income and vehicle ownership in Taiwan, presenting estimated asymmetric error correction models. The empirical data include information on household income, car ownership and motorcycle ownership in different regions from 1974 to 2009. The results show that, first, motorcycle ownership is asymmetrically cointegrated with household income in each region, and car ownership is asymmetrically cointegrated with household income in all regions except Taipei city. Second, both car and motorcycle ownership levels increase faster than they decrease in the asymmetric adjustment of their long-run relationship. Third, sensitivity tests for the period 1987–2009 show that the cointegration relationship of the car ownership equations vanished. Finally, we find evidence on the effects of household income on motorcycle ownership, and the effects of income variables on car and motorcycle ownership are dissimilar. This study exhibits different results across regions. These findings may be related to the development of public transit system in each region.

1. Introduction

In the developing world, designing policies that can effectively control the number of vehicles has become a major challenge for governments. Vehicle ownership also creates problems such as traffic congestion, inefficient travel, air pollution and excessive energy consumption. The existing literature on vehicle ownership models can be divided into two parts in terms of its approach. One body of studies has used macroeconomic analysis, including aggregated and time series data. In this context, the primary type of analysis model is the regression model (Jansson, 1989; Button et al., 1993; Mannering, 1983; Said, 1992; Stanovnik, 1990). However, approaches based on aggregated data assume that individuals are homogeneous and do not examine the behavioral factors influencing different individuals. The other body of studies has employed microeconomic analysis, including individual and cross-section data (Giuliano and Dargay, 2006; Matas and Raymond, 2008; Dissanayake and Morikawa, 2010). However, cross-sectional surveys cannot capture the impact of changes in variables over time. It was for this reason that Nolan (2010) used pool data in his dynamic analysis of car ownership.

Many previous studies have highlighted the nature of relationships between socio-economic characteristics and car ownership. A number of studies have been undertaken that have examined the effects of income on the ownership of cars, motorcycles or both (Dargay and Gately, 1999; Giuliano and Dargay, 2006; Dargay, 2002; Jou and Sun, 2007; Van Acker and Witlox, 2010; Potoglou and Kanaroglou, 2008; Clark, 2007; Whelan, 2007). Some studies have used household expenditure instead

* Corresponding author. Tel.: +886 04 2389 2088x3622.
E-mail address: michelle@teamail.ltu.edu.tw (W.-H. Huang).

0965-8564/$ - see front matter
doi:10.1016/j.tra.2012.01.001

of income to calibrate car ownership models (Matas and Raymond, 2008; Dargay, 2001, 2002). Some studies have also assessed effects on household vehicle ownership in the context of the household residential choices (Bhat and Guo, 2007), job accessibility (Matas et al., 2009) and public transport provision (Cullinane, 2002). Van Acker and Witlox (2010) used car ownership as the mediating variable in their study of car use and travel behavior, employing a structural equation model.

Another important determinant of household ownership is the geographical factors and socio-economic characteristics that affect different transportation systems. For example, Dargay (2002) examined the factors determining car ownership in households in urban and rural areas. Potoglou and Kanaroglou (2008) used an MNL model to calibrate the ownership model for Hamilton. Clark (2007) used weighted regression to estimate the car ownership for each of the electoral wards in the United Kingdom. Dargay and Gately (1999) used an econometrically estimated model to explain ownership as a function of income for OECD countries. The results of these studies show that the area factor is also an important component of the household ownership model. Jou and Sun (2007) suggest that policymakers create different policies to curb the increase in car ownership.

The literature shows that household vehicle ownership models are usually assumed to exhibit long-term equilibrium with regard to income variables. The traditional methods assume that the long-term relationship between household income and vehicle ownership is linear and symmetric. Thus, the responses of vehicle ownership to income variable are identical when income increases and decreases. Many studies have focused on the symmetric income effect on household ownership, but little attention has been paid to the asymmetric income effect on vehicle ownership. Dargay (2001) was the first study to offer an asymmetric view of this topic. In that study, the income factor was divided into two monotonic variables, non-negative and non-positive, to investigate the asymmetry using cohort data. The study also shows "stickiness" in the downward direction, and indicates that car ownership responds more strongly to rising income than to falling income.

Because an asymmetric relationship may exist between vehicle ownership and household income, it would be improper to describe that relationship using the traditional assumptions of linearity and symmetry. Therefore, we have employed the asymmetric threshold cointegration test developed by Enders and Siklos (2001) to examine the asymmetric relationship between household income and vehicle ownership in Taiwan and then to estimate the asymmetric error correction models.

In addition, we have taken the geographic factor into consideration because of the potentially different relationships between vehicle ownership and household income in different regions. In this study, there are four regions: the whole Taiwan (including Taipei and Kaohsiung cities), Taipei city, Kaohsiung city, and Taiwan (excluding Taipei and Kaohsiung cities).

The paper is organized as follows: Section 2 presents the empirical methods used in our study, Section 3 discusses the empirical context and our findings, and the final section presents our conclusions and suggestions.

2. The model

2.1. Cointegration

The cointegration method can be used to investigate the hysteresis characteristics of economic variables. If there is a linear relationship between economic variables that exhibit cointegration, this linear relationship can be interpreted as indicating that those economic variables also exhibit long-term equilibrium. Cointegration analysis is an important econometric tool used to estimate long-term relationships among economic variables.

Before proceeding with the cointegration analysis, we were obliged to use the unit root test to verify whether the variables under consideration were stationary. In a stationary series, the means and variances are constant over time. If a non-stationary series must be transformed to a stationary series by differencing d times, it is said to be integrated of order $\boldsymbol{d}$, denoted as $\boldsymbol{I}(\boldsymbol{d})$ (Engle and Granger, 1987). Only when the variables are integrated with the same order is it possible for the variables to be cointegrated.

We used the Augmented Dicky–Fuller (ADF) test which is the most widely used method of examining stationary series. It involves the following regression:

$$\Delta Z_t = \alpha + \beta T + \gamma Z_{t-1} + \sum_{j=1}^{k} \lambda_j \Delta Z_{t-j} + e_t \tag{1}$$

where Z_t is the variable being considered, Δ is the first difference operator, e_t is the random error, and k is the number of lagged terms that allows for the existence of autocorrelation in e_t. The null hypothesis in the ADF test is that the series is non-stationary. When the coefficient γ is statistically significant and smaller than the critical values, the null hypothesis is rejected. In other words, all characteristic roots lie within the unit circle, denoted as $\boldsymbol{I}(\mathbf{0})$. Because the time series may be possessed the effects of intercept and trend, the ADF test should be used with every possible type of series.

The ADF test is based on the assumption that the data are linear, and it would not be an appropriate method to use if the data were nonlinear. Therefore, to account for the possibility that our data are nonlinear, we also used the nonlinear unit root test invented by Kapetanios et al. (2003), which is named the KSS test. The KSS test is an extension of the ADF test that accounts for nonlinearity using the exponential smooth transition autoregressive (ESTAR) process.