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The asymmetric effects of gasoline prices on public transportation use in Taiwan

Ming-Che Chao [a], Wen-Hsiu Huang [b,*], Rong-Chang Jou [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, Ling Tung Rd., Taichung 40852, Taiwan

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ABSTRACT

This study investigates the asymmetric effects of gasoline prices on public transportation use in Taiwan. The empirical results obtained are as follows. First, we verify that gasoline price is an important determinant of transit demand. Gasoline prices have significantly positive effects on bus and mass rapid transit (MRT) use. Second, MRT ridership is more sensitive than bus and railway ridership to gasoline price and income. In the face of oil prices escalation and economic growth, the MRT system should have higher priority in public transportation planning. Third, the effects of gasoline prices on bus and MRT use are asymmetric. Bus and MRT use increases faster when gasoline prices rise than it decreases when gasoline prices fall. The transit agencies should adjust operating strategies faster in the rising of oil prices than in the falling of oil prices. It is important for transit planning to use oil prices as signals and increase the flexibility of operation in dealing with the changes in ridership. Some strategies, such as enhancing the availability of transfer information and updating transit information timely, are helpful to move passengers efficiently.

Overview

In Taiwan, almost 100% of the crude oil supply is imported. About 40% of all oil consumed is used for transportation. A survey of Taiwan's Ministry of Transportation and Communications (MOTC) showed that, in 2012, only 15% of trips were taken on public transportation. Nearly 71% of trips were made by car and motorcycle. It is imperative to reduce dependence on private vehicles and decrease oil consumption. Recently, because of high crude oil prices, the development of public transit systems has been of higher priority in energy policy. Rising oil prices may induce people to adjust their behaviour to save transportation costs. One option for people to reduce oil consumption is public transit. Thus, the relationship between gasoline prices and transit demand has drawn much more attention due to fluctuations in oil prices. It is important to discuss the following questions: "How does transit use respond to oil prices?" and "What is the relationship between oil prices and public transportation use?" If the relationship between transit use and gasoline price are clarified, the relevant strategies can be used to enhance public transportation usage in this era of high gasoline prices. In this paper, we further investigate whether the responses of transit ridership are different between a rise and a fall in gasoline prices.

There are quantitative studies investigating the determinants of transit demand. In terms of economic theory, transit demand is affected by the user costs. The gasoline prices will affect the cost of public and private vehicle use. One the

* Corresponding author. Tel.: +886 4 2389 2088x3622; fax: +886 4 23895293.
E-mail address: michelle@teamail.ltu.edu.tw (W.-H. Huang).

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one hand, an increase in gasoline prices will raise the fee for public transit. On the other hand, an increase of gasoline prices will also increase the user costs of private vehicles. Therefore, whether rising gasoline prices will promote public transport use depends on which effect is dominant. Most studies show that gasoline price does have a statistically significant impact on transit ridership. Increases in gasoline prices play an important role in encouraging transit use (Agthe and Billings, 1978; Wolff and Clark, 1982; Wang and Skinner, 1984; Litman, 2004; Haire and Machemehl, 2007; Currie and Phung, 2007, 2008; Maghelal, 2011; Frondel and Vance, 2011; Lane, 2010, 2012; Fujisaki, 2014). However, Kohn (2000) finds that gasoline price has no significant impact on transit ridership. Taylor et al. (2009) also claim that fuel price is only marginally significant; a possible reason for this finding is that there is relatively little variation in average fuel prices. Milioti and Karlaftis (2014) show that gasoline price only have a small positive effect to bus share both in the short and in the long run.

The elasticity of transit ridership with respect to gasoline prices is also a parameter of concern in this research field. Many studies show that the values of elasticity are positive and inelastic. In other words, the value of the elasticity is somewhere between 0 and 1 (Wang and Skinner, 1984; Haire and Machemehl, 2007; Currie and Phung, 2007, 2008). Moreover, the previous research shows that the responses of transit ridership to gasoline prices vary across transit modes and countries (Currie and Phung, 2007, 2008). Fujisaki (2014) suggested that the effects of gasoline prices on transit ridership would be different between the megalopolis-region and non-megalopolis-region. Mattson (2008) indicated that gasoline prices may not affect ridership in the same way for all transit agencies. Transit buses that operate longer routes could be affected differently from those that operate shorter routes. Litman (2004) and Nowak and Savage (2013) suggested that bus and rail often have different elasticities because they serve different markets. Nowak and Savage (2013) also found that the cross elasticities between transit ridership and gasoline prices were larger when gasoline prices increased.

Most previous studies investigated the relationship between transit use and oil price under the assumption of linear relationship. These studies have modelled oil price effects on transit use as symmetric, but little attention has been paid to potential asymmetric oil price effects on transit ridership. Because an asymmetric relationship may exist between gasoline prices and transportation use, it would be improper to describe that relationship using the traditional linearity and symmetry assumptions. Balke and Fomby (1997) indicate that when variables undergo asymmetric adjustments, the traditional linear cointegration model lacks power and generates errors in estimation. Enders (2003) suggests that asymmetric behaviour may exist in economic variables. The asymmetry would exhibit in the differential speed or size of adjustment. Kitamura (1990) indicates that asymmetric behaviour could occur for the reason of hysteresis. The asymmetry effects of gasoline prices on transit use should be considered for two reasons. One possible reason is the asymmetry of price transmission. Gasoline prices may appear asymmetric, typically rising more quickly than they fall (Bacon, 1991). The other reason is the effects of announcement and expectation. People perceived the rises in gasoline prices more quickly than the falls. Thus, the change of transit behaviour may be different between fluctuations in gasoline prices. Chen et al. (2011) use the autoregressive fractionally integrated moving average (ARFIMA) model to analyse the impact of changes in gasoline prices and transit fares on transit ridership in the New York city. They examine whether there is symmetry in the response of ridership to increases and decreases in gasoline prices and transit fares. The results show that elasticities are different between rising and falling gasoline prices. This study notes an interesting phenomenon that transit ridership responds to rises in gasoline price, but not to falls.

In light of these results, we employ the asymmetric threshold cointegration test developed by Enders and Siklos (2001) to examine the potentially asymmetric relationship between gasoline prices and transportation use in Taiwan. If there is an asymmetric cointegration relationship, transit agencies should have differential operation policies and make service changes according to the fluctuations of gasoline prices. Litman (2004) suggests that analysing how price changes affect transit ridership has many practical applications in transportation planning, such as predicting transit demand and revenue, controlling vehicle traffic volumes and pollution emissions, and evaluating the benefits of mobility management strategies. From the perspective of the policy maker, analysis of the asymmetric relationship between oil prices and public transportation use is meaningful for forecasting transit demand, evaluating the impacts on environment, and making effective policies to face fluctuations in oil prices.

Methods

Cointegration

The concept of cointegration was first introduced by Granger (1981). The estimation procedure and the cointegration test were developed by Engle and Granger (1987). Engle and Granger (1987) indicated that a linear combination of two or more non-stationary series may be stationary. If a stationary linear combination exists, we can say that the non-stationary time series are cointegrated. The stationary linear combination is referred to as the cointegration equation, and it may be interpreted as a long-run equilibrium relationship among the variables. In other words, even if the variables may wander around in the course of time, they cannot drift too far apart from each other. The deviations from equilibrium are stationary, with finite variance, even though economic variables are nonstationary.

Cointegration analysis is an important econometric tool used to estimate the long-run relationship between variables. The application areas of cointegration are very extensive in the economic issues. However, cointegration studies in the transportation field are few. For example, Liddle (2012) and Jou et al. (2012) employed the cointegration methods in the analysis