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Truck freight demand elasticity with respect to tolls in New York State

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ABSTRACT

Road pricing is an important travel demand management strategy and its effects on transportation system has been widely investigated. Toll elasticity has been derived in the existing literature to characterize its effect on travel demand all around the world. However, very few studies have comprehensively analyzed the effect of tolls on freight transportation, which plays an increasingly important role in social and economic activities. To enrich the understanding of freight travel demand, this study conducted a stated preference survey on freight carriers who routinely use toll facilities. A regression model about freight carriers' stated reduction in vehicle miles traveled (VMT) on toll roads is then developed. The elasticity value is derived and compared with values in existing literature. Based on the calibrated model, the VMT change in response to hypothetical toll price increases is simulated for New York State. The simulation results reveal important insights that will help policy makers design ideal freight demand management strategies.

1. Introduction

Road pricing has been perceived as an effective method to reshape travel patterns, and consequently improve road usage efficiency and reduce emissions. Understanding the effect of road pricing requires comprehensive investigation of travel behavior, which is believed to be influenced by travelers' socio-economic conditions, vehicle types, and road conditions, among others. It is also noticed that, however, behaviors differ significantly between passenger transportation and freight transportation. Passenger vehicles' travel pattern is typically determined by drivers and riders. As a result, travel demand can be attributed to drivers' and riders' occupation, income and family sizes. Freight trips, on the other hand, are not only influenced by truck drivers, but also agents in other stages of supply chain, including at least receivers and shippers (D. Zhang and X.C. Wang, 2016). Therefore, analyses of freight travel demand also need to consider the characteristics of these agents, who vary significantly in size, organizational structure, and industrial sector. Because of these differences, effects of road pricing on passenger and freight transportation need to be distinguished. However, most existing literature focused on either passenger transportation or the overall transportation without distinguishing passenger and freight trips. Investigations focusing exclusively on freight travel demand under the influence of road pricing are fairly limited. With the increasingly important role of freight transportation, insufficient understanding of road pricing may lead to improper travel demand management strategies. This research fills this void by analyzing road pricing elasticity of freight travel demand.

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Existing literature found that freight travel demand is influenced by many factors including the price of transported commodities, fuel charges, and operation expenses (Zou et al., 2017; Ni et al., 2016). Elasticities with respect to these factors have been derived using different methods and data. However, the effect of road pricing has not been adequately studied. Most studies simply assessed the sensitivity of freight travel demand by comparing the observed traffic volume before and after the change in road pricing. For example, Bari et al. (2015) examined the change in truck traffic on SH 130 in Austin, Texas after the toll rates fell. These investigations using revealed preference methods may not be comprehensive due to the following reasons: (1) Revealed preference may not obtain sufficient variation to examine all factors of interest; and (2) Revealed preference methods cannot evaluate freight travel demand corresponding to road pricing that does not exist in practice (Kroes, 1988). An attractive alternative is the stated preference method that collects information about freight carriers' potential behavior change. Freight travel demand elasticity with respect to road pricing can be then derived with econometric models. Literature using survey data to analyze freight travel demand mainly comes from a series of the time-of-day pricing studies (Holguin-Veras et al., 2006; Soro and Wang, 2012; Holguín-Veras, 2008, 2010) where the objective is to move truck traffic to off-peak hours. Another key branch of literature investigates road pricing from the perspective of truckers' route choice. For example, Arentze et al. (2012) used experiments to examine the sensitivity of truckers' behavior in response to pricing policies in a route choice context. However, the main focus was not to obtain travel demand elasticity. Given the lack of comprehensive examination of freight demand elasticity with respect to road pricing, this research conducts a stated preference survey in New York State to investigate this issue. Based on the results of the model, a simulation is then conducted to demonstrate the change in vehicle miles traveled (VMT) on the surveyed toll road in response to toll-price increases.

The stated preference survey of this study collects rich information about freight carriers' behavior. The respondents are the managers of logistic companies that frequently use toll roads in New York State. The survey first collects the characteristics of these companies, such as size, types of commodities delivered, and origin/destination of each company's typical deliveries. Each respondent is then given three hypothetical toll-increase scenarios and asked to indicate their tendency to reduce VMT on the toll road. As each respondent faces with multiple scenarios which lead to a repeated choice problem, an ordered probit model with repeated choices is estimated to obtain marginal effects of influential factors.

The paper is organized as follows: the next section reviews existing literature. Data description and methodology are then introduced. Results analysis and a simulation study are discussed, followed by conclusions.

2. Literature review

2.1. Road pricing elasticity

Travel demand is affected by demographics, economic activities, travel modes, land use, and travel costs (Zhang and Wang, 2014, 2015; D. Zhang and X. Wang, 2016). The travel costs include monetary costs for fuel, insurances, vehicles, tolls, etc. Among them, toll, or road pricing, can be set by transportation agencies to influence travel demand on roads, and is therefore considered as an effective travel demand management strategy. The effect of road pricing can be characterized by elasticity, which is often negative, indicating that the increase in road pricing would result in a reduction of travel demand.

Road pricing elasticity has been widely investigated in the existing literature and most studies do not distinguish the types of vehicles. Earlier studies derived the elasticity by changing the flat toll fees by a certain amount and analyzing the change in traffic volume (Burris, 2003). Recent studies further investigated elasticity of variable toll fees in different time-of-day and congestion levels (Holguin-Veras et al., 2006; Holguín-Veras, 2008, 2010).

The elasticity values have been summarized by Litman (2013) and Burris (2003). Table 1 lists the values of elasticities found in literature in the recent two decades.

Table 1
Elasticity estimation in existing literature.

Source	Range of elasticity	Location
Mauchan and Bonsall (1995)	−0.25 to −0.40	West Yorkshire, UK
Gifford and Talkington (1996)	−0.18	San Francisco
Inrets (1997)	−0.22 to −0.35	France
Luk (1999)	−0.1 to −0.6	Singapore
Lawley Publications (2000)	−0.2	New Jersey
Burris (2001)	−0.03 to −0.36	Florida
Odeck and Kjerkreit (2002)	−0.5 to −0.8	Oslo, Norway
Matas and Raymond (2003)	−0.21 to −0.83	Spain
Odeck and Bråthen (2001)	−0.3 to −0.8	Norway
Odeck and Kjerkreit (2010)	−0.52 to −0.75	Norway
Börjesson et al. (2012)	−0.70 to −0.86	Stockholm, Sweden