

21st International Symposium on Transportation and Traffic Theory, ISTTT21 2015, 5-7 August
2015, Kobe, Japan

A Two-Stage Approach to Modeling Vacant Taxi Movements

R.C.P. Wong, W.Y. Szeto*, S.C. Wong

Department of Civil Engineering, The University of Hong Kong, Hong Kong

Abstract

In this paper, a two-stage modeling approach is proposed to predict vacant taxi movements in searching for customers. The taxi movement problem is formulated into a two-stage model that consists of two sub-models, namely the first and second stage sub-models. The first stage sub-model estimates the zone choice of vacant taxi drivers for customer-search and the second stage sub-model determines the circulation time and distance of vacant taxi drivers in each zone by capturing their local customer-search decisions in a cell-based network within the zone chosen in the first stage sub-model. These two sub-models are designed to influence each other, and hence an iterative solution procedure is introduced to solve for a convergent solution. The modeling concept, advantages, and applications are illustrated by the global positioning system data of 460 Hong Kong urban taxis. The results demonstrate that the proposed model formulation offers a great improvement in terms of root mean square error as compared with the existing taxi customer-search models, and show the model capabilities of predicting the changes in vacant taxi trip distributions with respect to the variations in the fleet size and fare. Potential taxi policies are investigated and discussed according to the findings to provide insights in managing the Hong Kong taxi market.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Selection and peer-review under responsibility of Kobe University

Keywords: two-stage approach; taxi customer-search; enhanced sequential logit model; logit-opportunity model; global positioning system data

1. Introduction

In many cities, taxis always circulate in search of customers, but this circulation consumes much road space. Especially, when many vacant taxis are concentrating at central business districts (CBDs) in customer-search, the

* Corresponding author. Tel.: +852-2857-8552; fax: +852-2559-5337.
E-mail address: ceszeto@hku.hk

local traffic congestion and air pollution problems are deteriorated. For better controlling the vacant taxi movements, numerous studies have been focused on examining the consequences on implementation of taxi regulatory policies in forms of entry restrictions and price controls (e.g., Douglas, 1972; De Vany, 1975; Manski and Wright, 1976; Beesley and Glaister, 1983; Schroeter, 1983; Arnott, 1996; Cairns and Liston-Heyes, 1996; Xu et al., 1999; Yang et al., 2000, 2002, 2005a, 2010a; Flores-Guri, 2003; Fernández et al., 2006; Moore and Balaker, 2006; and Loo et al., 2007). However, these studies have been developed based on an idealized market of conventional economic analysis in which the spatial structure of the market was ignored.

In an attempt to capture the spatial structure of the market, Yang and Wong (1998) developed a model to determine the taxi movements on a given road network. In this model, the customer-search behavior of taxi services is based on the assumption that each vacant taxi driver attempts to minimize his/her expected search time to find a customer. Later, the model was further improved by Wong and Yang (1998), Wong et al. (2001, 2002, 2005, 2008), Yang et al. (2001, 2005b, 2008, 2012), Yang and Yang (2011), Kim et al. (2005), and Hu et al. (2012) to capture congestion effects, multiple user classes, multiple taxi modes, customer hierarchical modal choice, taxi search behavior of taxi customers, day-to-day learning processes, stochastic travel time, and search frictions between vacant taxis and taxi customers. Yet, the assumption has ignored the case that vacant drivers travel to remote areas to pick up customers because of the high profit return.

Taken into account the profitability consideration, Wong et al. (2003) developed a taxi network model to explicitly examine the effects of perceived profitability on the customer-search behavior of vacant taxis and the expected profit that taxi drivers could earn by picking up customers in particular zones. Yang et al. (2010b) further extended this concept to “profit per unit time” by incorporating the operational cost and time consumption involved in taxi trips to maximize profits from customer-search. However, the search behavior models in the preceding taxi network models are in logit form and have not been calibrated and validated.

Until recently, Sirisoma et al. (2010) provided an empirical evidence to validate the search behavior models. They determined the significant factors that affect vacant taxi drivers’ customer-search decisions based on the data collected from a stated preference survey. Wong et al. (2014a) calibrated and validated multinomial logit (MNL) models based on their global positioning system (GPS) data obtained from urban taxis to predict the drivers’ strategic zone choices for searching for customers in both peak and off-peak periods. Szeto et al. (2013) further extended the consideration to every hour in a day. Wong et al. (2015a) considered the sequential customer-search decisions of vacant taxi drivers on finding customers at intermediate zones while heading to their designated zones, and proposed an enhanced sequential logit (ESL) model to additionally predict search paths as compared with the model of Wong et al. (2014a). However, the preceding behavior models often predicted the strategic zonal decisions of vacant taxi drivers for customer-search and ignores the local (within zone) search behavior that as vacant taxi drivers search for customers, the probability of successfully meeting a taxi customer along the way increases. In addition, the probability of a vacant taxi driver meeting a taxi customer decreases if there are many vacant taxis nearby. This important fact has not yet been considered. Therefore, these models cannot be used for developing simulation-based models and simulation-based optimization models for depicting and managing taxi flows on the local streets.

For modeling the local search behavior of vacant taxi drivers, Hu et al. (2012) recently proposed a probabilistic dynamic programming vacant taxi routing model to depict the routing decisions of vacant taxi drivers at intersections according to the passenger arrival rate. Wong et al. (2014b) formulated a cell-based network and modeled the local search behavior of vacant taxi drivers based on the probability of successfully meeting the next taxi customers. Nevertheless, these studies assumed that vacant taxi drivers seek to minimize their expected time spent searching for their next customer nearby or to maximize the probability of successfully meeting a taxi customer. This assumption is realistic when modeling the search behavior in urban areas, where the length of customer trips may not significantly vary from zone to zone, and where taxi drivers may not have much information about the profitability of going to particular zones to search for customers. However, this assumption may not reflect the real situation in more remote areas with considerable potential demand (e.g., an airport or satellite town). Even though the search time to remote areas is longer than that at urban areas, numerous vacant taxis still go there to wait for customers because the drivers expect to earn more by doing so.

A two-stage taxi customer-search model is therefore proposed in this study to predict vacant taxi movements to address the above issues by integrating and formulating the zonal and local search problems of vacant taxi drivers. In fact, the integrated transportation modeling concept has been widely adopted for formulating multi-stage transportation problems to ensure that the obtained outcomes from different stages are consistent with each other. In

Download English Version:

<https://daneshyari.com/en/article/1106923>

Download Persian Version:

<https://daneshyari.com/article/1106923>

[Daneshyari.com](https://daneshyari.com)