Transport Policy 52 (2016) 16–27

Contents lists available at ScienceDirect

Transport Policy

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

Curbside parking pricing in a city centre using a threshold

Rong Zhang [a], Lichao Zhu [a,b,*]

[a] College of Transportation Engineering, Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, 4800 Cao'an Road, Jiading District, Shanghai 201804, PR China

[b] Institute of Transport and Logistics Studies, The Business School, The University of Sydney, NSW 2006, Australia

ARTICLE INFO

Article history:
Received 19 December 2015
Received in revised form
16 June 2016
Accepted 24 June 2016

Keywords:
Curbside parking
Parking pricing
Discrete choice
Cut-off
Pricing scheme

ABSTRACT

How to set reasonable pricing for curbside parking, while balancing the demand for and the supply of parking spaces, is a troublesome problem for metropolitan areas such as Shanghai. This paper addresses this problem from the perspective of choice behaviour. Our research focuses on the parking charge cut-off point, which is the minimum or maximum acceptable value that a driver sets for an attribute. A multiple linear regression model reveals that older and inexperienced drivers are more likely to ignore the charge cut-off points they themselves have set. Discrete choice models incorporating charge cut-offs are further used to analyse charge implications for parking choice behaviour. Our results show that the precision of the conventional model is improved by including a cut-off. At the same time, parking charges, the time spent searching for a parking space, and walking time after finding the parking space, all have a significantly negative influence on parking choices. Finally, a pricing scheme is put forward to reduce the occupancy rates of curbside parking to 85%. This contention is based on parking pricing models with cut-offs. We find indications that not accounting for charge cut-off points, when they are in fact present, may lead to inaccurate willingness-to-pay and upwardly biased pricing schemes.

1. Introduction

Curbside parking pricing has received significant attention from economic theorists (Arnott et al., 1991; Shoup, 2004; Proost, Van Dender, 2008). However, a common approach found in existing literature is to determine a curbside pricing scheme without considering garage parking pricing and the interaction between the two. If curbside and garage parking are perfect alternatives to each other, then curbside parking prices should be equal to garage parking prices, in order to achieve the goal of eliminating cruising (Shoup, 2005; Arnott and Inci, 2006). However, the two types of parking are not perfect alternatives, because of spatial differences (Arnott and Rowse, 2009). More specifically, approximately 30% of traffic is drivers cruising while looking for parking. This finding is based on a study of 11 international cities (Shoup, 2004). In addition, the average time taken to find a curbside parking space is between 3.5 and 14 min (Arnott and Inci, 2006). This finding indicates that drivers prefer curbside parking over garage parking, due to curbside parking's flexibility, convenience, conservation of land and low construction and maintenance costs. However, curbside parking spaces occupy public road resources. Therefore, how to balance a road's occupancy rate and its functional goals is an important problem (Zhang et al., 2013; Zhang and Zhu, 2015). Reasonable curbside parking pricing can not only reduce vehicle cruising time and the number of cruising vehicles, but such pricing can also help to improve curb parking resource utilization. Shoup (2004) proposed that an 85% occupancy rate is appropriate for curbside parking spaces. Shoup stated that charge increases are needed when a road's occupancy rate exceeds 85%, in order to guarantee that drivers can find parking spaces any time. In other words, a city should try to optimize the use of public garages, rather than maximize the revenue of governments or companies (Pierce et al., 2015). At the very least, maximizing revenue is not the most important goal. At the same time, setting a reasonable parking price without having an adverse impact on the transportation system and other systems of a city is difficult (Simićević et al., 2013). This is especially true in cities in developing countries, due to the absence of reliable parking data. We are committed to addressing this issue in metropolitan areas

* Corresponding author at: College of Transportation Engineering, Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, 4800 Cao'an Road, Jiading District, Shanghai 201804, PR China.

E-mail addresses: zhangrong@tongji.edu.cn (R. Zhang), 2012zhulichao@tongji.edu.cn (L. Zhu).

http://dx.doi.org/10.1016/j.tranpol.2016.06.008
0967-070X/

such as Shanghai. In what follows, we present a general introduction to the parking situation in Shanghai.

Corresponding with the continuous improvement of residents' living standards, the number of private cars in Shanghai increased rapidly, from 1.5 million in 2009, to 3.2 million in 2014. This represented a 113% increase. Meanwhile, the number of parking spaces in downtown Shanghai grew from 0.77 million to just 1.13 million, an increase of only 47% (Shanghai Bureau of Statistics, 2014). The above fact indicates that the average annual growth rate of transportation facilities is lagging far behind that of the growth rate in the ownership of private cars. “Difficult to drive, difficult to park” has become one of the most important messages affecting the investment environment and socio-economic development of Shanghai. In addition, according to the 2014 Shanghai curbside parking statistics data, the ratios of parking durations of less than 1 h, between 1 and 2 h, and more than 2 h was 61.53%, 25.70%, and 12.77%, respectively, with a growing trend of average parking durations (Zhang et al., 2015). This tendency leads to an average turnover rate of only 3.09 times per day for each parking berth (Zhang et al., 2013). Based on this finding, the city's curbside parking pricing needs to be adjusted, especially in those key areas where curbside parking resources are relatively scarce. Therefore, we endeavour to propose a reasonable parking pricing scheme to influence a portion of vehicle drivers to change their main parking spots from curbside to garage parking. Our aim is to reduce the occupancy rate of curbside parking to 85% (or any other reasonable value that local government wants to achieve). At the same time, we take parking charge cut-offs into consideration to avoid a bias in price adjustments. These cut-offs represent the minimum or maximum acceptable values that a decision maker assigns to an attribute. Once the attribute value is outside the acceptable range, the driver may not choose this option (Swait, 2001; Danielis and Marcucci, 2007).

2. Related works

Scholars have dedicated considerable effort to examining parking issues (Simićević et al., 2012). These scholars have used various methods, including mathematical programming (Feng and Zhu, 2008), discrete choice (Hess and Polak, 2004; Dell'Olio et al., 2009; Kobus et al., 2013), linear regression (Ottosson et al., 2013), average pricing (Cheng et al., 2012), game theory (Zong et al., 2013), and other models (Arnott and Rowse, 2009; Mei et al., 2010; Caicedo, 2012; Simićević et al., 2012). All these methods attempt to analyse parking-related issues. Their models can all be classified as choice, allocation and interaction models (Young et al., 1991). In particular, using discrete choice models (DCMs) to predict a driver's response to parking behaviour has gradually become more popular (Hess and Polak, 2004; Simićević et al., 2013). In addition, the use of DCMs in parking-related issues has been summarized in van der Waerden et al. (2002) and Hess and Polak (2004). Among DCMs, the multinomial logit (MNL) model (Spiess, 1996; Teknomo and Hokao, 1997; Hess, 2001; Washbrook et al., 2006; Simićević et al., 2013) and nested logit (NL) model (Bradley et al., 1993; Hunt and Teply, 1993; Hensher and King, 2001; Lu et al., 2015) have a major position in parking behaviour research. Lately, researchers have started to pay closer attention to more advanced models, such as the mixed multinomial logit (MMNL) model (Bhat and Castelar, 2002; Hess and Polak, 2004; Ibeas et al., 2014). These models reveal drivers' preferences in parking choices, with most parking choice models estimated using stated preference data (Ibeas et al., 2014).

The common use of DCMs indicates that these models appear to be helpful in exploring the relationship between parking charges (or other attributes) and parking behaviour, and not only because of the relative simplicity of their implementation (Albert and Mahalel, 2006; Marsden, 2006). Classic studies on the relationship between parking charges and mode choice include those conducted by Kuppam et al. (1998), Hensher and King (2001) and Washbrook et al. (2006). For example, Hensher and King (2001) applied the NL model to reveal the contribution and impact of curfew and parking rates on parking's market share. By constructing an MNL model, Washbrook et al. (2006) simulated the effect of road charges and parking charges on the probability of an individual choosing to drive alone to work. However, these scholars did not present a clear and workable curbside parking pricing adjustment scheme to governors or operators. In addition, typical researches which used the MMNL model include Hess and Polak (2004) and Ibeas et al. (2014). As far as we know, Hess and Polak's (2004) study was the first paper to construct the MMNL model as a means to reveal drivers' taste variations for access time, search time, egress time, parking fees and expected fines. Nevertheless, these researchers ignored the impact of driver characteristics on parking choice behaviour, whereas Ibeas et al. (2014) further included driver characteristics to investigate parking behaviour in a coastal town in Spain. Ibeas's results show that variations in the age of vehicle, income and residence will significantly affect driver behaviour and willingness-to-pay (WTP). In addition, the coefficients of parking charges and the time spent looking for a space vary across the population. Both of these findings will enlighten parking governors and operators attempting to determine pricing guidelines for different districts and users.

Based on the aggregation and comparison of related works, we found two deficiencies in existing literature. The first deficiency is these studies have little consideration for the diverse acceptance of different drivers in terms of parking charges. This lack of consideration caused the researchers to either overestimate or underestimate driver responsiveness to parking charge changes. The second deficiency is that the above-named studies lack the consideration of the effect of driver characteristics on their parking choice behaviour. This failure will result in biased estimators and less accurate simulation results. Therefore, it is essential to study the influence of a parking charge threshold and driver characteristics on parking choice behaviour, in order to determine a reasonable curbside parking pricing scheme with the goal of an 85% occupancy rate. In addition, our study will also help to fill in the relationship gap between the number of parking charge cut-off violations and drivers' socio-economic characteristics.

The structure of this paper is as follows: Section 3 describes two different types of parking behaviour analysis models. Our survey methodology and elementary statistical analysis of data is presented in Section 4, where the relationship between the number of parking charge cut-off violations and individual characteristics is further analysed. Section 5 describes how to construct parking choice models which incorporate charge cut-offs, and in which different models are compared. Based on Section 5, a rational parking pricing scheme is proposed in Section 6. Section 7 provides the conclusions drawn from our research results, as well as avenues for further research.

3. Model specifications incorporating a cut-off

3.1. Conventional model

The basic idea of DCMs is that a decision maker, i.e. a driver in this case, obtains a certain level of utility from each alternative, all