Transportation Research Part A xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part A

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

Rethinking performance based parking pricing: A case study of SFpark

Tayo Fabusuyi*, Robert C. Hampshire

Transportation Research Institute, University of Michigan, 2901, Baxter Road, Ann Arbor, MI 48109, United States

ARTICLE INFO

Keywords:
Curb parking
Price elasticity
Panel data
Random effect
Policy scenarios

ABSTRACT

In an effort to reduce circling and cruising in cities' central business districts (CBDs), a number of cities have begun implementing pricing programs that modify parking rates based on observed occupancy levels. We improve on this pricing mechanism by developing a forward-looking policy instrument. The instrument employs a two-stage panel data regression and optimization model that influences demand for parking spaces by changing parking rates via computed price elasticities of parking demand measures. Coefficient estimates that include the elasticity measures from the panel data regression are used to fit a linear prediction model that is the primary input to the optimization model.

An application of the approach is presented using SFpark, a federal government-funded demonstration program in San Francisco as a case study. We evaluate the effectiveness of the modified pricing mechanism by comparing actual occupancy and parking rate tuples with the optimized result to ascertain the potential improvement in SFpark's performance. Policy scenarios are subsequently explored by carrying out sensitivity analysis primarily through SFpark pricing rules. Relative to SFpark's figures, our model yielded approximately 16% improvement in systems performance when measured by the number of blocks that deviate from the 60 to 80% occupancy target. Our findings highlight the importance of moving towards a predictive regime that allows for proactively managing the parking program compared to a reactive approach based on observed parking occupancy.

1. Introduction and motivation

In an effort to eliminate circling and to reduce parking search time and cruising, SFpark, an innovative demand-responsive pricing program, was implemented by the City of San Francisco in April 2011. Over a period of 13 months, the program was piloted across seven San Francisco neighborhoods made up of over 6000 metered spaces with the objective of moving parking blocks towards a 60–80% parking occupancy range. This objective contrasts with vehicle turnover goals and/or revenue considerations that are typically the interest of cities' parking programs. Other secondary goals associated with the SFpark program include reduced greenhouse gas emissions, traffic congestion and ensuring the economic viability of the City's central business districts.

Historically, on-street parking rates are static; often set lower compared to off-street parking options and decoupled from transportation goals (San Francisco Municipal Transportation Authority, 2011). The rates are typically determined at City Halls with the objective of funding other programs; for example, a pension plan that may be underwater and at risk of being taken over by the state. Consequently, demand for parking spaces are not taken into consideration. In addition, perverse incentives are created for

* Corresponding author.
E-mail address: Fabusuyi@umich.edu (T. Fabusuyi).

https://doi.org/10.1016/j.tra.2018.02.001

Please cite this article as: Fabusuyi, T., Transportation Research Part A (2018), https://doi.org/10.1016/j.tra.2018.02.001

circling and cruising by not reflecting the true cost of curb parking relative to off-street parking. Finally, no provision exists with regards to exploiting synergies between on-street parking assets and the city's broader transportation goals.

The SFpark program improves on these shortcomings by implementing a spatio-temporal price adjustment mechanism that modifies parking rates across both parking period and parking blocks based on presently observed occupancy levels. For any adjustment period, the latest parking occupancy levels are compared with the desired 60–80% parking occupancy range. Prices are revised downwards by $0.25/hour for blocks at less than 60% average parking occupancy in the previous period and increased by $0.25/hour for those blocks at occupancy levels in excess of 80%. Rates remain unchanged for blocks within the desired 60–80% parking occupancy range. This pricing rule wrestles control of parking rates from City Hall but more importantly, ties the rate changes to parking demand. An evaluation conducted by San Francisco Municipal Transportation Agency (SFMTA), the agency directly responsible for managing the SFpark program, concluded that considerable value has been added by the program and that the program has been able to move parking occupancy in the right direction (San Francisco Municipal Transportation Authority, 2014), a viewpoint echoed by Pierce and Shoup (2013).

The program's effectiveness, particularly with regards to the relationship between price changes and parking occupancy levels, has however been met with mixed reviews by other studies (Chatman and Manville, 2014; Millard-Ball et al., 2013). Millard-Ball et al. (2013), for example, were able to replicate Pierce & Shoup's finding using simulated parking demand derived from a simple random process. Based on this finding, they argue that no evidence exists of the impact on parking occupancy from rate changes and suggest that arriving at a conclusion on the effectiveness of SFpark's demand response pricing may be premature. This assertion was corroborated by the work of Chatman and Manville (2014) that found no relationship between the parking rate modifications and parking availability although a later work by Millard-Ball et al. (2014) that used a richer longitudinal dataset found a relationship, albeit a small one, between rate changes and parking occupancy.

Of direct relevance to the conflicting findings and the present study is the lever by which price changes influence demand – price elasticity of parking demand measures. Approximately 35% of the price elasticity measures obtained by Pierce and Shoup (2013) were positive. Secondly, about 40% of the elasticity figures have absolute values in excess of 1 – indicating elastic measures that are contradicted by previous empirical works on parking demand (Ottosson et al., 2013) or by what conventional wisdom would have one believe. It is thus problematic making the case for using these figures as the primary input for a forward-looking policy instrument.

We address the concerns itemized in the previous couple of paragraphs by using price elasticity measures derived from a panel data regression analysis in an optimization model. Estimating parking elasticity measures using panel data methods extends the boundary of knowledge on this subject given that, to the authors' knowledge, this is the first empirical study to derive plausible price elasticity of parking demand estimates using panel data methods. Predicted parking occupancies are subsequently generated by modifying parking rates via the estimated elasticity measures. This approach facilitates improvement to the program through policy prescriptions and provides flexibility that allows for the use of different priority structures.

Various approaches have been used to predict the demand for parking spaces particularly for CBDs. Teng et al. (2008) for example, provided parking prediction based on information exchanged between wirelessly connected vehicles. Others include the use of agent-based modeling in simulating drivers' behavior (Martens and Benenson, 2008) and in dynamically predicting parking demand using a multi-agent crowdsourcing approach (Tilahun and Serugendo, 2017). Caicedo et al. (2012) provided an excellent example where predicted parking requests via an information parking reservation (IPR), are routed to a number of competing facilities. The body of work also includes the use of neural networks in predicting parking demand (Fabusuyi et al., 2014; Vlahogianni et al., 2016); and an assignment model with generalized cost approach as shown by Lim et al. (2017). While the present study shares some similarities with the aforementioned, our approach is distinct primarily in two ways – a novel policy instrument that uses a two-stage panel data regression and optimization model and more importantly, none of the earlier studies cited explicitly sought to influence the predicted parking demand in a manner that is socially beneficial.

The balance of the paper is organized as follows. A review of existing literature and related works on vehicle parking are provided in Section 2. Section 3 addresses data sources and provides an overview of the empirical strategy. Detailed information on the subsets of the empirical strategy including the optimization model and the panel-data regression model is provided in Sections 4 and 5 respectively. Results and discussion of findings are presented in Section 6. Caveats associated with the findings are discussed in Section 7. Section 8, the last section, wraps up with the conclusion and provides insights on areas for further studies.

2. Review of existing studies

Parking in the United States takes up a vast amount of space with the total land area for a typical given day estimated to be as large as the state of Massachusetts (Jakle and Sculle, 2004). Apart from the land area dedicated to parking, a by-product of the demand for parking spaces, especially for cities' central business districts, is cruising and the attendant congestion, pollution and other negative externalities it creates. Shoup (2011) for example, observed that in a 15-block business district in Los Angeles, more than 100,000 h are wasted annually by drivers cruising for parking. Arnott and Inci (2006) has characterized this behavior – cruising for parking, as an example of the tragedy of the commons.

Historically solutions to parking problems have been supply-oriented, but with limited public financing for new supplies of parking, these initiative have shifted, of late, to a more demand-side approach (Inci, 2015). These include policy prescriptions oriented towards providing information or modifying parking rates with the objective of achieving desired average parking occupancy thresholds by time and space. While the implementation of this concept may be a relatively novel development, the idea itself is far from new. Vickery (1954) as far back as 1954 argued for a spatio-temporal differential pricing for parking; charging different