Transportation Research Part A 63 (2014) 76–92

Contents lists available at ScienceDirect

Transportation Research Part A

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

Is the curb 80% full or 20% empty? Assessing the impacts of San Francisco's parking pricing experiment

Adam Millard-Ball [a,*], Rachel R. Weinberger [b], Robert C. Hampshire [c]

[a] University of California, Santa Cruz, Santa Cruz, CA 95064, United States
[b] Nelson|Nygaard Consulting Associates, New York, NY 10001, United States
[c] Carnegie Mellon University, Pittsburgh, PA 15217, United States

ARTICLE INFO

Article history:
Received 9 October 2013
Received in revised form 31 January 2014
Accepted 11 February 2014
Available online 31 March 2014

Keywords:
Parking management
Parking pricing
Cruising
Queuing theory
SF*park* parking search

ABSTRACT

The city of San Francisco is undertaking a large-scale controlled parking pricing experiment. San Francisco has adopted a performance goal of 60–80% occupancy for its metered parking. The goal represents an heuristic performance measure intended to reduce double parking and cruising for parking, and improve the driver experience; it follows a wave of academic and policy literature that calls for adjusting on-street parking prices to achieve similar occupancy targets. In this paper, we evaluate the relationship between occupancy rules and metrics of direct policy interest, such as the probability of finding a parking space and the amount of cruising. We show how cruising and arrival rates can be simulated or estimated from hourly occupancy data. Further, we evaluate the impacts of the first two years of the San Francisco program, and conclude that rate changes have helped achieve the City's occupancy goal and reduced cruising by 50%.

1. Introduction

Parking management has been a vexing problem for cities since the invention of the automobile. One concern is excess travel, congestion, air pollution and greenhouse gas (GHG) emissions that are caused by drivers searching for available parking – an activity colloquially known as *cruising*. Studies of cruising date to 1927, and some researchers have estimated that upwards of 30%, and maybe as much as 50%, of traffic on a given downtown street is comprised of people searching for a parking spot (Shoup, 2006; see also Schaller Consulting, 2006; Shoup, 2008; Arnott and Rowse, 1999). In particular, Shoup (2005) estimated that cruising in one small area of Los Angeles produced 3600 miles of excess travel each day – equivalent to two round trips to the Moon each year.

One common response by cities has been to require developers to provide "sufficient" off-street spaces to accommodate expected demand for free parking and to provide municipal garages to make up for shortages at the curb. Indeed, many cities in the United States had introduced off-street parking requirements for new development by the mid-1960s, and such policies have worked to prevent cruising in low-density, suburban and newly developed areas. But, in denser urban centers, competition at the curb has persisted, frequently combined with off-street surpluses. Hence, the wisdom of such parking requirements has recently come into question. Moving away from a policy of copious, free off-street parking places an additional premium on curb management. If off-street parking is provided at a higher cost than on-street alternatives, drivers rationally choose to cruise, driving the increased need for curb management (Shoup, 2006; Arnott and Inci, 2006).

* Corresponding author. Tel.: +1 831 459 1838.
E-mail address: adammb@ucsc.edu (A. Millard-Ball).

http://dx.doi.org/10.1016/j.tra.2014.02.016
0965-8564/

The need for on-street management has long been recognized. In 1935, the magazine *Popular Mechanics* reported that Oklahoma City, the first city to do so, introduced parking meters in order to enable customers to a commercial area to find a space more easily (Popular Mechanics, 1935); and a 1956 book by the United States Bureau of Public Roads recommends maintaining a curb occupancy rate of no more than 85–90% in order to mitigate cruising (Bureau of Public Roads, 1956). During the 1970s and 1980s, many cities lost sight of this need. Unable to foster the political will to effectively manage their curbs these cities suffered double parking; parking in loading zones, bus stops and in front of fire hydrants; and increased cruising. However, there has been a recent wave of interest in price-based curb management to mitigate these problems. Cities as varied as San Francisco, Seattle, Pasadena, Budapest, Mexico, D.F. and Seoul have set parking occupancy performance standards and adjusted prices to meet the performance goals.

Among these cities, San Francisco has piloted and carefully documented an extensive and innovative parking management program (SF*park*). One of the hallmarks of SF*park* is the availability of occupancy data, which we use in this paper to address two related questions. First, we examine the theoretical and empirical relationships between parking performance standards – typically expressed as keeping average occupancy within a certain range – and the outcomes of policy interest, such as the driver's experience and the amount of cruising. Second, we provide an evaluation of the effectiveness of SF*park*. We do not attempt to separate the effects of the individual components of SF*park*, such as information provision and price changes. Rather we examine travel behavior impacts of the program as a whole.

The contributions of this paper are theoretical, methodological and empirical. On the theoretical side, we show how different measures of parking performance, such as occupancy, relate to the driver experience and cruising. On the methodological side, we develop techniques to estimate cruising, arrival rates and the probability that a block is full from aggregated occupancy data. We then apply these theoretical and methodological tools to an empirical analysis of a large-scale controlled dynamic pricing experiment, SF*park*. While one might expect that increased prices would reduce occupancy and cruising, the magnitude of any impacts is not obvious *ex ante* – particularly since price adjustments are small and are not immediately visible to drivers.

The following section reviews existing work on cruising and measuring the performance of parking systems, and then shows how this work can be informed by insights from the large literature on queueing theory. We then introduce the empirical setting of San Francisco, and describe the SF*park* program and our sources of data. Subsequent sections discuss the simulation model of cruising that we calibrate using data from SF*park*, and present the model results in terms of cruising and other measures of parking performance. We conclude by discussing policy extensions and directions for future research.

2. Understanding parking performance

2.1. Cruising research

Cruising is a long-standing concern for cities. For example, Shoup (2006) identifies 16 empirical cruising studies conducted between 1927 and 2001. In more recent years, numerous cruising studies have been added to this collection. Empirical studies rely on some kind of driver survey (Schaller Consulting, 2006), videotaping (King, 2010), or driving and searching by car (Shoup, 2006). This last technique has been criticized as adding to cruising, thus changing the fundamental terrain of the study. Driver surveys generally stop people at intersections to ask if they are seeking parking, or ask people emerging from their cars about their experience finding a parking place. Studies that rely on video – or other visual techniques – may be the most robust. They count vehicles passing an open space and infer that the inverse of one plus the number of vehicles to pass an open space is equal to the proportion of traffic that is looking for parking.

The other class of cruising studies is theoretical; this work is well represented in the economics literature. Most analyses conclude that cruising is due to misallocation of resources and should be eliminated (Arnott and Inci, 2006; Button, 2006). An extension of Arnott and Inci (2006) is due to Arnott and Rowse (2009) who look specifically at spatial competition between curb parking and garages. One study suggests that street parking should be priced equivalent to the marginal cost of providing an additional off-street space (Calthrop et al., 2000).

In contrast to a marginal cost pricing approach, Shoup (2006) recommends that on-street prices be set to achieve an average occupancy level of 85%, with an explicit rationale of eliminating cruising. Though Anderson and de Palma (2004) question the premise that cruising should be entirely eliminated, the Shoup rule-of-thumb requires that price vary both throughout the day and across different blocks, in order to achieve the occupancy goal. The rule-of-thumb has gained wide policy traction and, as noted above, occupancy targets have been introduced in places including Budapest, Seattle and Mexico, D.F. A similar approach with a slightly lower occupancy target has been adopted as part of SF*park*. A recent empirical analysis of the San Francisco case by Pierce and Shoup (2013) shows a relatively elastic demand for parking on blocks where meter prices have been adjusted. Unfortunately, that work fails to address the endogeneity of the price adjustments, which complicates our ability to interpret their findings (Millard-Ball et al., in press).

In spite of widespread acceptance of the 85% or similar occupancy standard, very few studies have sought to analyze the heuristic empirically. The existing literature – primarily based on theory (Qian and Rajagopal, 2013; DÁcierno et al., 2011; Bagloee et al., 2012); stated preference surveys (Kelly and Clinch, 2006; Barata et al., 2011; Simićević et al., 2012, 2013; Ahmadi Azari et al., 2013); and simulation models (Benenson et al., 2008; Martens and Benenson, 2008) – suggests that cruising would decrease as prices adjust to achieve the target occupancy. However, it is also possible that rate changes would