Understanding Dynamic Pricing for Parking in Los Angeles: Survey and Ethnographic Results

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Abstract. The field of parking is going through a period of extreme innovation. Cities in the United States are now exploring new technology to improve on-street parking. One such innovation is dynamic pricing based on sensors and smart meters. This paper presents the results of two surveys and an ethnographic study in the context of LA Express Park™ to understand users' behaviors, knowledge and perceptions around parking. Survey results demonstrated that a high number of users misunderstood one of three tested stickers that convey time of day pricing. Furthermore, after discovering the availability of cheaper parking spots nearby, people expressed willingness to change their future behavior to park in those places. Ethnographic field studies found that it is common for many parkers to use handicapped placards for over eight hours in one parking session. A percentage of these parkers may be using placards illegally. We propose that increasing some parking restrictions during the day may curb placard use by making it more difficult to park for long periods.

Keywords: Parking technology, dynamic pricing, ethnography.

1 Introduction

In many urban centers traffic is becoming an issue because of congestion and its associated effect on air quality. Technology related to parking has evolved relatively slowly since the first parking meter was installed in 1935 [14]. Recently, however, cities around the world have begun to experiment with the use of technology to improve the parking experience. One way technology is being used is the use of dynamic pricing as a means to reduce congestion. With the support from the United States Department of Transportation, cities like San Francisco (SFPark, 2013) and Los Angeles (LA Express ParkTM, 2013) have installed sensors that report the occupancy of each street parking space and new parking meters that charge variable rates depending on time of the day. [6, 11, 16]. Moscow, Barcelona, Toulouse, Auckland,

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and Indianapolis [3, 4, 12, 19, 23] are just a few of the other cities around the world who are experimenting with sensors and technologies to help drivers find and pay for parking. Washington DC has also piloted sensors in a four block area and has plans to expand that pilot to 1000 spaces [15]. Likewise, New York City has incorporated 177 magnetic sensors in a pilot program, ParkSmart [8].

In this paper, we address these emerging questions in the context of LA Express Park™. We first review related work in the field of dynamic pricing for parking. Then the results from two surveys and an ethnographic study conducted in Los Angeles are presented. We conclude with recommendations about how to improve the dynamic pricing for parking from a user's perspective.

2 Related Work

In this part, we give a brief review of the sensor based parking management system which supports dynamic pricing for parking. We then review related work in the literature on the effectiveness of dynamic pricing for parking.

2.1 Sensor Based Parking Management System

The technology that allows demand based pricing is wireless parking sensors that are typically embedded in the center pavement within the parking spot. The sensors detect the change in parked vehicles' occupancy and these data are then used to determine parking availability. In turn, motorists have real-time information about available parking through websites and applications while enforcement officers, with the combination of meter payment data, are able to see potential violations. A variety of parking sensors are available including solar and battery-powered sensors based on a variety of magnetic, optical, ultrasonic and radar techniques [20]. Although sensors have been used in off-street parking for some time, it has not been widely adopted in on-street parking management because of the higher cost of on-street sensor installation due to the need for wireless communication. Generally, sensors need demarcated spaces in order to accurately assess parked vehicles, and may not always work if people parking don't park in expected ways. [17]

2.2 Dynamic Pricing

Cruising the streets to find an open space for parking is common and greatly increases traffic congestion. It is estimated that an average of 34% of cars in congested downtown traffic are cruising for parking [18]. Economists have advocated matching prices to demand as an effective way to solve parking problems. Nobel prize winning economist William Vickery recommended that street parking prices should be set "at a level so determined as to keep the amount of parking down sufficiently so that there will almost always be space available for those willing to pay the fee" [22]. However, the primitive metering technology in 1954 made the proposal of dynamic pricing appear outlandish [13]. Following Vickrey, several theoretical economic analyses of parking demonstrated that cruising could be eliminated by an adequate pricing policy [1, 2, 7].

Recent developments in sensor and payment technologies have made dynamic demand based pricing of parking a reality. It has also afforded the possibility of time of day pricing meaning that times/days when demand for parking is low, rates are low and visa versa. Pierce and Shoup's research on SFpark showed that time of day pricing is effective in reducing on-street parking occupancy rates and that the average price elasticity for parking is -0.4 (every 10% increase in parking price leads to a 4% fall in occupancy).

The above-mentioned studies focused on using mathematical methods to model driver's driving and parking behavior and showed some positive potential of using dynamic pricing for parking, yet there are still many unanswered questions in this area. For example, it is not clear what drivers' reactions are to the concept of dynamic pricing for parking. Drivers may not know that the price of parking is dynamic and thus the question of how to communicate the concept of dynamic pricing to drivers is essential to its success [13].

Further, dynamic pricing of parking works in some places, but not in others and it is not always clear what attributes to its success or demise. There are several noted obstacles to achieving the desired results from congestion pricing that include infrequent enforcement, meter failures, government vehicles (that are exempt from payment) and those drivers with handicapped placards (also exempt from payments in certain U.S states and cities). The California vehicle code allows handicapped parkers to park for as long as they want at no cost [5].

In this study, we took a user-centered approach to explore dynamic pricing and to gain deeper understanding about people's reactions and behavior with regard to dynamic pricing of parking in the context of LA Express ParkTM.

3 LA Express Park™

In 2010, the Los Angeles Department of Transportation began a process of installing new parking meters in downtown Los Angeles that accepted credit and debit card payments. A network of wireless payment sensors keep track of parked vehicles and help officials determine what meters are currently in use. The key goal of the program is to increase availability of parking spaces and decrease traffic congestion and pollution.

Stakeholders wanted to develop communication strategies to inform parkers of cheaper parking nearby, test current communication strategies and develop new ways to convey the complexity of time of day pricing. The implementation of time of day pricing in August 2012 further highlighted the need for a clear communication strategy and required new ways to convey the complexity of variable pricing.

3.1 Dynamic Pricing Stickers

A sticker design solution was implemented to convey pricing information for two conditions. One sticker design was developed for meters in blocks where a range of rates were available in a small geographic area but where time of day pricing had not yet been implemented. The goal of this sticker was to easily convey to the parker where they were, the price of parking where they parked and the relative price of

parking on nearby block faces (Figure 2). The sticker was designed to fit on the front facing side of the meter. We created many iterations of the sticker to find the optimal design for driver comprehension.

The second scenario for which stickers were designed was time of day pricing (AKA variable rate pricing). Previously, the city of Los Angeles conveyed time of day pricing information using a sticker known as the Max Rate sticker (Fig. 3, left part of figure). This sticker conveyed the maximum rate a user would pay, but did not answer the question: "What is the price of parking right now?" A new sticker was developed to be more descriptive about the range of hourly rates throughout the week (Fig. 3, right portion).

(a) (b) (c)

Fig. 1. a: Flat rate sticker; **b:** Maximum rate sticker; **c:** time of day sticker

The key research questions related to these stickers on which data collection was targeted were: How well did parkers comprehend the stickers? What were parkers' intentions around future parking behavior because of TOD pricing? What were people's knowledge of parking fees? What were people's knowledge of recent parking price increases?

4 Methods

On-street Intercept Survey. We developed an intercept survey and conducted open-ended interviews with individuals parking in four pilot areas. Each of the four areas included one block face with a relatively higher hourly parking rate and neighboring block faces with less expensive rates. Individual water resistant stickers were developed and placed on meters (see Fig.2). Anyone parking within the pilot block area qualified to participate. Respondents received twenty dollars if they agreed to answer the survey questions and talk with us for a few minutes after the survey was complete.

During the week of February 11 and the week of March 19, 2013, ethnographic observations and intercept surveys were conducted on those four downtown Los Angeles streets. Seventy-three (73) people of different ages (from 20s to 60s) were interviewed in intercept surveys.

Online Targeted Survey. To reach a larger population and understand the general acceptance of the concept of dynamic pricing of parking, we worked with a third party survey firm and launched an online survey targeted at people in the Los Angeles area. As a result, responses from 158 participants were collected. See Table 1. below for detailed demographic information about the participants in each survey.

In both surveys, we asked questions about people's awareness of dynamic pricing for parking and their comprehension of different dynamic pricing stickers.

Table 1. Demographic information of survey respondents

	Intercept Survey *(N=73)*	Online Survey *(N=158)*
Age	<=20: 4.3% 21-30: 23.2% 31-40: 34.8% 41-50: 26.1% 51-60: 10.1% >60: 1.4%	18-24: 11.26% 25-34: 15.23% 35-44: 15.23% 45-54: 21.85% 55-64: 25.83% 65-74: 7.95% >75: 2.65%
Gender	Male: 63.2% Female: 36.8%	Male: 54.3% Female: 45.7%
Education	NA	High school or less: 5.3% Undergraduate degree: 61.59% Graduate degree: 23.18% Professional: 9.9%
Annual Income	NA	<$25k: 25.4% $25k-$50k: 13.3% $50k-$100k: 21% $100k-$150k: 14.7% >$150k: 26.6%

Ethnographic Observations. In addition to the surveys, ethnographic observations were conducted to understand any social and physical aspects related to parking in the four pilot areas. Observations were targeted to identify any routinized patterns of behavior among parkers; who is parking and why; the physical environmental elements present that might affect parking in the pilot areas; and to understand the human need fulfillment that is attempted to be met (vis a vis parking) within the pilot settings. Information on Handicapped Placard parking was a result of these observations and became a primary finding of the study.

5 Results

In this section we first report on results from the intercept and online surveys which include: factors influencing parking decisions, awareness of parking prices, distance parked from intended location, comprehension of dynamic pricing stickers, possible

changes in behavior, and feelings about dynamic pricing. Second, we will report the findings on handicapped placard observations.

5.1 Factors Influencing Parking Decisions

Proximity is the most important factor that people consider when selecting a parking space while time is the least important factor. In the online survey, participants were asked to rank how the following factors influenced their decision when selecting a parking space (1 as least important, and 4 as most important): availability of parking spots; cost of parking; proximity of the parking spot; and, time (whether in a rush or not). Proximity is rated as the most important factor people would consider when deciding where to park, with a weighted average score of 2.99. Cost is the second most important factor with a weighted average score of 2.50 and availability the third most important factor (weighted average score of 2.46). Time is the least important factor (weighted average score of 2.03).

In the intercept survey, similar questions were asked and similar results were obtained. Instead of asking participants to rank the importance of factors, we ask participants to choose all the factors that they think are important. Proximity was considered by 63.8% of the respondents as an important factor that influences their parking decisions, followed by 33.3% of the respondents who thought availability was an important factor. Cost was regarded by 18.8% of the participants as an important factor while only 7.2% of the respondents regarded time as a factor to consider when selecting a parking spot.

In the intercept survey, respondents also mentioned other factors to consider when choosing a parking space. Included as other factors were fear of being towed and safety concerns.

5.2 Awareness of Parking Prices

In both the online and on-street intercept surveys, participants' awareness of dynamic pricing was studied. More specifically, participants' awareness of recent parking price changes (Price Change), awareness of time of day dynamic pricing for parking in downtown Los Angeles (TOD Pricing) and awareness of the availability of mobile parking apps were assessed. If the participant indicated that they were aware of some mobile parking applications, they were asked to identify the names of those mobile parking applications.

In general, participants' awareness of recent parking price changes; time of day dynamic pricing for parking and the availability of mobile parking apps was low (Fig. 4). In the online survey, 31 (20%) participants were aware of price changes, while in the intercept survey, 22 (31%) participants said that they were aware that parking prices changed in downtown Los Angeles.

About 20% of the participants in the online survey indicated that they were aware of TOD pricing in downtown Los Angeles, and this is consistent with the results from the intercept survey where 17 participants (24%) indicated that they were aware of TOD pricing.

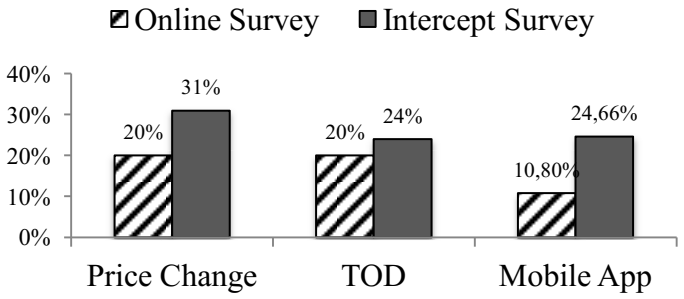

Fig. 2. Awareness of price change, TOD and mobile parking apps

People's awareness of the mobile parking application were particularly low. Only 17 (10.8%) of the participants in the online survey indicated that they were aware of mobile parking apps, and only 5 of them could name a mobile parking app. In the intercept survey, a higher percentage of the participants claimed that they were aware of some mobile parking apps (18 or 24.66%), but only 4 of them could name a mobile parking app.

It is noted that participants' awareness of price changes, TOD and mobile parking applications is always lower in the online survey group than in the intercept survey group. This may be due to differences in the characteristics of the two samples participating in each survey. The online survey respondents tended to be older and more females were respondents. Further, based on our experience, we felt that it was because in the intercept survey participants had the opportunity to interact with the researchers and the researcher can briefly clarify or explain things that participants did not quite understand at the beginning. For example, some of the participants did not quite understand the concept of TOD in the beginning, but after explaining it to them, they confirmed that they were aware of it. However, the combination of results from both surveys should provide sufficient representativeness to offer reasonable generalization of results as responses tended to be in the same direction in both groups.

5.3 Distance Parked from Intended Location

In the on-street intercept survey we asked respondents how many blocks from their intended location they actually had to park. Over half (54.79%) parked within one block of their intended location.

We then asked survey respondents "What is the maximum number of blocks you would be willing to park from your intended location. The mean number of blocks that respondents were willing to walk was 3.07 (SD = 1.54).

5.4 Comprehension of Dynamic Pricing Stickers

We tested comprehension of three types of stickers. For the flat-rate sticker (Fig. 2), overall comprehension of the sticker was quite high with over 80% of respondents from both samples answering the questions correctly. We asked respondents three questions.

First, "From looking at the sticker above, what is your current location?" Eighty-three percent (83%) of intercept survey respondents and 91% of online survey respondents answered this question correctly. Next we asked, "From looking at the sticker above, what is the price of parking where you are right now? Similarly, 92% and 85% answered this question correctly. Finally we asked, "From looking at the sticker above can you identify which of the following streets has the least expensive parking? Eighty-nine percent (89%) and 86% answered this question correctly.

For the intercept survey we approached comprehension of the Max Rate sticker (Fig.3, left) with an open-ended question to respondents: "What does this sticker mean to you? Not surprisingly, we found that only 20.9% of those we spoke with accurately understood the intended message of the sticker. In contrast, for the online survey we asked respondents to select among multiple choices that included the following: 1) "The price of this spot can change, but won't go over $3/hour;" 2) “Parking is $3/hour; and 3) The parking limit is one hour. Roughly 7 in 10 respondents (69.1%) correctly identified the answer: “The price of this spot can change, but won't go over $3/hour.” We believe that the disparate findings are due to the open ended versus multiple choice response formats and the time online respondents had to consider the question as well as the setting. Upon careful consideration the Max Rate sticker would appear to be sufficiently clear in its meaning. However, in a test environment, more participants are able to identify the correct answer when they have the ability to select that answer among three choices. In contrast, when on the street and directly asked, people’s first impression was that it is $3/hour.

5.5 Behavioral Change Intentions

In the online survey, we asked respondents “Now that you know there is cheaper parking nearby, would you be inclined to park where there is cheaper parking on your next visit?” Roughly 84% of the respondents expressed willingness to change their parking based on flat rating pricing. This finding is consistent with results from the intercept survey (76.4%), across genders (Chi square (1, N=151)=.47, p=.49) and groups with different levels of income (Chi square (1, N=113)=.07, p=.78).

In the online survey, we also asked, "How likely is Time of Day pricing to affect your parking behavior?" Approximately 48.4% of the respondents were somewhat or extremely likely to change their parking based on TOD, however about another 32.5% of the respondents were unlikely to change their parking behavior. This result is consistent with the result from the on-street intercept survey (49.3% of them were likely to change their parking based on TOC).

5.6 Feelings about Dynamic Pricing

We asked participants to provide reasons when they indicated that they were unlikely to change parking behavior based on TOD pricing in both the online and the intercept surveys. The following themes emerged:

- People with inflexible schedules (business, employment, etc.) are unlikely to change their parking based on TOD.
- People who don’t park frequently in downtown LA or don’t park long hours were also unlikely to adjust their parking based on TOD pricing.

- Convenience of parking and availability of parking spaces are other factors that influence people's parking decisions. Some people care more about parking convenience than cost.
- The fact that parking price would increase during peak hours intensifies the competition between public on-street parking and private garage parking.

To summarize, it is interesting to observe that the discussion of parking choices correspond quite nicely with what theory predicts. The valuation for a close on-street space is different for different types of users. In particular, short stay parkers will be less influenced by a rate change. Longer stayers, who are less inconvenienced by walking to a nearby off-street lot will be the first to change their parking location. And by doing so, they will open up spaces for users that have a higher benefit to park close and for short stay parkers (shoppers, etc.).

5.7 Ethnographic Observations: Handicapped Parking Placards

Our ethnographic observations revealed that many streets were full of cars parked with handicapped placards. In this section we discuss these observations in more detail and propose a potential solution.

The First Encounter. South Oliver Street (at 7th) has 21 on-street parking spots. However, this location was virtually full of vehicles with handicapped placards. As a result, there was no turnover and we were unable to conduct interviews. We were intrigued with the number of placards and noted that as the observation days progressed we observed the same vehicles parking on or near this particularly block. As by Manville [21], one of the significant roadblocks to achieving the desired behavior change via economic interventions to pricing is handicapped parking. Drivers for whom price doesn't matter affect overall pricing and demand because one can't affect behavior change with this subset of parkers because price doesn't matter.

We observed this particular block systematically for two days, on March 20th and 21st, 2013. We counted the number of handicap placards in vehicles parked in legal spaces 4 times during the day over the two days and observed the following. On average, 75% of cars parked had handicap placards. We observed many people who parked with handicap placards walking presumably to their place of employment nearby without any detectable physical handicapping condition. The percentage of occupied spots with handicapped placards peaked at midday (Fig.3). When spots opened up, paying customers filled them.

Handicapped Parking Placards in Downtown LA. We also identified nine blocks that were known to have high handicap placard usage (learned from city parking enforcement officers) and we observed these blocks on at least one occasion. Four out of the nine blocks have different parking restrictions on two sides of the street. We found that occupancy rates of handicapped placards were higher on sides of the streets that had fewer parking restrictions. For example, on the block of 700 & 701 S Flower St, on the side of the block where there is parking available between 8 AM and 8 PM, 60% of the occupied spots had vehicles with handicap placards. On the opposite side of the street with tighter restrictions (9AM - 3 PM), there were no placard users.

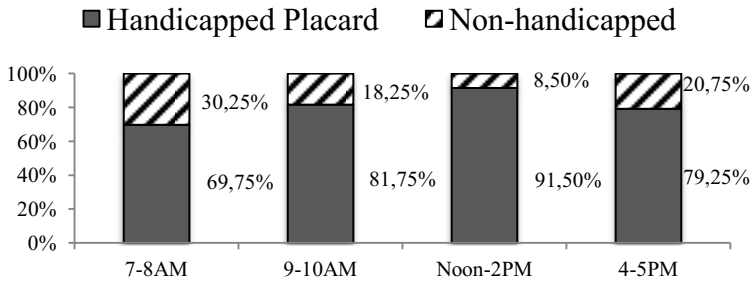

Fig. 3. Handicapped placard occupancy rate on South Oliver Street (at 7th)

We combined all the data that were collected on those four blocks, and found that handicapped placard usages was much lower on the side of the street where there are more parking restrictions (chi-square (1,N=103)=13.97, p=.0002).

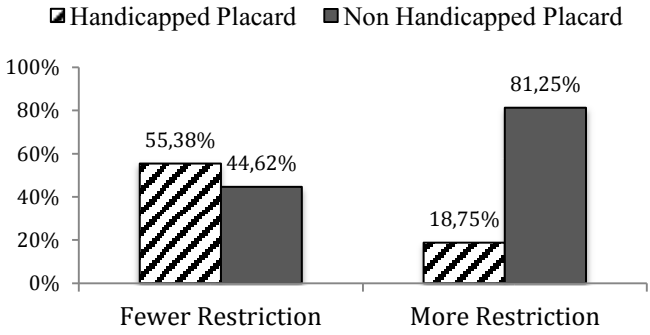

Fig. 4. Handicapped placard rate comparison

6 Discussion and Conclusion

In this paper, the results of two surveys and an ethnographic study on users' behaviors, knowledge and perceptions about dynamic pricing for parking are presented. While most of the previous work on dynamic pricing for parking heavily focused on using mathematical models to demonstrate the efficacy of dynamic pricing for parking to reduce traffic congestion and make more parking spots available, our study contributes to the literature by taking a human centered approach to understand the dynamics around parking.

As presented, we found that overall comprehension of the stickers were quite high. However, it appeared that those individuals who had more difficulty were those for whom English is a second language, or for those who may appear to have low literacy levels. This is an important point to consider in any public design consideration.

While as a pilot, the flat rate sticker was an interesting way to alert people that there was cheaper parking nearby. The time of day sticker also demonstrated a feasible way to communicate pricing. The actual implementation of these stickers as a

permanent solution to the problem of promoting behavior change and communicating pricing is challenging. The practicality of recreating the sticker as parking prices change could be time consuming and a burden. The tenant of demand based pricing is that prices of parking should change relative to demand. It is unfortunate that at this time, adoption of smart phone applications that help you find and pay for parking is relatively low. Until technology can guide people to cheaper parking, it will be difficult to affect behavior change. As we noted in the beginning section, Apple recently announced integration of their IOS in vehicles. This will help facilitate guided navigation to cheaper parking. There will always exist several individuals for whom these technologies are not available, so the problem of conveying pricing information in a low-tech way will likely continue in one form or another.

In this study it was found that there was high incidence of handicap placard usage in downtown Los Angeles. We observed many people who parked with handicap placards easily walking presumably to their place of employment nearby. Further it was found that in places where there were more parking restrictions (9AM - 4PM vs. 8AM-8PM), the incidence of handicap placard was much lower. This is a promising result because in the short term, policy makers can potentially solve some of the handicap parking issues by adjusting the parking restrictions. However, it is suggested that larger scale experiments are needed to verify the aforementioned hypothesis and it is feasible given the fact that this data could be gathered from sensors.

In the longer term, technologies that can help parking enforcement officers easily identify illegal handicap placards are in great need. We noticed that another important reason that contributes to the high incidence of handicap placard in LA is that it is hard to verify a legitimate placard for a legitimate user. Someone could simply get a handicap placard from his or her grandparents. It is also easy to get a fake placard from the black market. Thus, it is suggested that there are three main technologies to be tackled. The first challenge is how to verify the validity of a given placard and the second is how to verify that the current user of a given placard is a valid user. The third challenge is how to design a technology that is user friendly and efficient. The ultimate goal is to design technologies that can protect legitimate handicap placard users' benefits while at the same time making sure that on-street parking, a public and social resource, is properly utilized in the interests of the whole society.

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