ASEE 2014 Zone I Conference, April 3-5, 2014, University of Bridgeport, Bridgpeort, CT, USA.

Decision Making Analysis on Parking Meters

Ruzanna Davtyan
Department Of Technology Management
University Of Bridgeport
Bridgeport, CT, USA
rdavtyan@hotmail.com

***Abstract*—this paper examines the use of on-street parking meters to answer questions about parking behavior, violations, enforcement, and revenue. As a case study the City of Stamford was used. It uses two sources of data: (1) historical data about parking meter performance for a period of over twenty years, 1965-1986; (2) a survey of selected on-street parking meter sites in downtown Stamford. It shows that an increased enforcement and penalties reduce illegal parking, while an increase in the value of walking and searching time will increase this activity**

Keywords—decision analysis, parking meter, violation.

I. Introduction

On-street parking meters are important part of American city. The objectives of these parking meters are: to promote parking revenue; to provide short-term parking spaces for; to improve traffic circulation. The parker himself activates a mechanism which begins immediately to count time is supposed to make him/her aware of when his/her time expires, and eventually lead to better observance of parking regulations, compared to non-metered areas(Kerley, 2007). All of this is true so long as the drivers obey the law, park only for the legal time limit, and pay the required fee. However, it is common knowledge that parking regulations in general, and those concerning parking meters in particular, are often violated. Rose termed parking violations as “folk crime,” which means that “the population that engages in illegal parking is virtually a replication of the entire adult community (Ross, 1960) p.34.’. Many researchers consider parking violation as a normal activity. The illegal parker considers that the expected value of being caught is small. It saves walking time, searching time, and parking fee. Based on Gur and Beimbom tested model “the increased enforcement and penalties reduce illegal parking, while an increase in the value of walking and searching time will increase this activity(Gur & Beimborn, 1984) p.45.”

II. Survey of Parking Behavior

A. *Objectives:*

- To estimate whether it is worthy for a costumer to pay the meter or not to pay the meter.
- To estimate whether it is profitable for the city of Stamford to maintain the meters in the in this part of the city.

B. *Hypothesis:*

Before collecting any data, our hypothesis were the following:

- The average amount of money that costumer spent on these 24 meters was $1.00.
- The probability of getting a ticket was 0.5.
- The Parking authority officer would visit the site every couple of hours.

C. *Setting Description:*

The data was collected from 24 parking meters located on Summer Street in the city of Stamford. These meters are located in front of a shopping plaza with about 22 stores including big stores such Bed Bath & and Beyond and small ones such Starbucks. The shopping mall has also a private parking lot where store costumers do not have to pay.

D. *Meter Description:*

The observation was on 24 single space meters. The operation time of these meters is from 8:00 AM to 6:00 PM. The minimum charge for the meter is $25 cents for 15 minutes and a limit time of 2 hours. Each additional $25 is worth 15 minutes.

E. *Collection of Data:*

The observation took place in five different weekdays from approximately 3:00 PM to 5:00 PM. The following information were recorded during this observations:

- Whether the parking space was occupied or not
- The time left on the meter
- The number of cars that got tickets

The meters were numbered form 1to 24 and each checking round was every six minutes. For instance, meter 1 was checked at 3:00 PM and meter 24 was checked at around 3:05. After this, the second checking round started exactly at 3:06

from meter 24 and back to meter 1. The maximum amount of time for one round back and forth was around 12 minutes. This way, we were able to record if the meter had extra minutes compared with the previous check. Therefore we were able to calculate the amount of money spent on each meter during these two hours. We minimized the checking times to the best of our ability in order to be able to count the number of parked cars without paying.

III. DATA ANALYSIS

For the purpose of this project the following decisions and events are considered:

D1 = Pay meter

D2 = Do not pay meter

E1 = Get a ticket

E2 = Do not get a ticket

Based on these two decisions and two events four possible outcomes are possible:

	E_1	E_2
D_1	$O_1 = < E_1, D_1 >$ Pay & No Ticket	$O_2 = < E_2, D_1 >$ Pay & No ticket
D_2	$O_3 = < E_1, D_2 >$ Do not pay & Ticket	$O_4 = < E_2, D_2 >$ Do not pay & No ticket

Table 1: Outcome Matrix

Each of the four outcomes is associated with a value in dollars. Based on the data collected:

- Average amount of money spent by customers who use the parking spaces is $ 0.46.
- The cost of getting a ticket is $ 15.45. $ 15 for the ticket and $ 0.45 for postage.

	E_1 (Get Ticket)	E_2 (No Ticket)
D_1 (Pay)	(O_1) = -$ 0.46	(O_2) = -$0.46
D_2 (Do not pay)	(O_3) = -$15.45	(O_4) = $0.00

Table 2: Outcome Matrix with specific outcomes values

The conditional probabilities associated with each of the outcomes are represented in table 3.

	E_1	E_2	Sum
D_1	$p(E1/D_1) = 0$	$p(E2/D_1) = 1$	1
D_2	$p(E_1/D_2) = 9/185 = .05$	$p(E2/D_2) = 176/185 = .95$	1

Table 3: Conditional Probability Matrix

Based on the data collected in the 10 hours of observation, the number of cars that parked that had either 0 time from the beginning or ran out of time is 185. Only 9 cars out of the 185 got tickets.

The following table shows the expected values for the costumer's decision of either pay or do not pay the meter:

	E_1	E_2	Expected Values
D_1	$(O_1) * p(E_1/D_1) = 0$ -$ 0.46 * 0	$(O_2) * p(E_2/D_1) = 1$ -$ 0.46 * 1	-$0.46
D_2	$(O_3) * p(E_1/D_2)$ -$15.45*.05 = -0.7725	$(O_4)*p(E2/D_2) = 176/185$ $0.00 * 0.95	-$ 0.7725

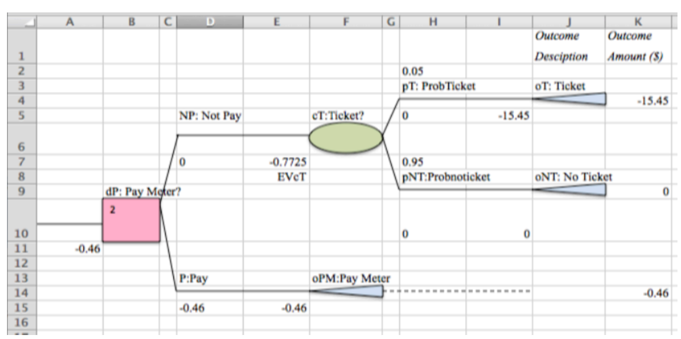
Table 4: Expectation Matrix

Comparing the expected values of either taking decision 1(D_2 = Pay Meter) or decision 2 (D_2 do not pay the meter), we can see the expected value for D_1 (-$0.46) is much lower than the expected value for D_2 (-$ 0.7725). Therefore it is better for the costumer to pay the meter, which is D_1.

IV. DECISION TREE

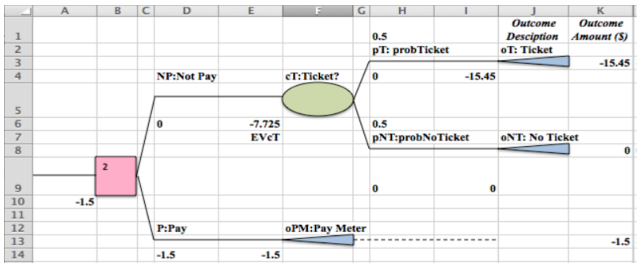
Due to direct and simple outcomes, the parking meter problem can be directly examined in the three tables: "the desirability's matrix, the probabilities matrix, and the expectations matrix (Fayyad & Irani, 1992) p.23." In general, decision outcomes may be separated from major decisions by many events and decisions. Decision trees that help us exemplify complex decision problems. They present a clear and graphical picture of the decision problem, ease a mathematical calculations for decision analysis (Kerley, 2007).

The following picture is a diagram of a Decision Tree, which is a graphically representation of the information in the above tables. In this case the pink square represents a decision node of paying or not to paying the meter. If the customer pays the meter, it comes to an end node representing that the costumer had spent - $0.46. In regard to the decision of not paying the meter, the green oval represents the chance of getting a ticket. In this case the expected value of getting a ticket is -$0.7725. After that, the diagram shows two end nodes, which are the representation of the cost t of either ticket or not ticket. The program makes a decision, which in this case match our conclusion above of paying the meter.



Picture 1. Decision Tree for the experiment

The Decision Tree bellow follow the same logic as the one above but it is a representation of our original assumptions of average of money spent per costumer equal to $1.50 and probability of getting a ticket equal to 0.5. In this case, the better decision for a customer is to pay the meter. As the diagram shows, the expected value of not pay the meter equal to -$ 7.725 which is higher than the expected value of paying the meter equal to -$1.50example, do not differentiate among departments of the same organization). This template was designed for two affiliations.



Picture 2: Decision Tree for Hypothesis

During the collection of data, we found out the parking authority officer does not come to check the meters on Mondays, Tuesdays and Wednesdays. Therefore, we analyze our data to see the difference in activity and income between Monday and Friday. These with the purpose of finding out whether our data supported the decision of the city of not sending an officer to this site.

	% of occupancy	Income
M/Tu/W	50 %	$18.75
Th/F	76%	$ 27.50

Table 5: The difference in activity and income between Monday and Friday

V. Analysis of Meters Profit

The results show an increment of 150% increase in activity and also an increase an income. Therefore the city probably thinks that it is more likely to give a tickets when there is more activity. To estimate whether it is profitable for the city of Stamford to maintain the meters in this part of the city we used the data provided by the city to estimate the profit from the meters of the entire city. Based on that data, there are 2,640 meters in the city. The Total Yearly Cost of these meters (installation, electricity, salary, and vehicle) is $4,132,000. The Estimated Income for the year, based on the data provided by the city (if all the parking spots are occupied all the time and people always pay the right amount of money), is $21,528,000. The Estimated Gross Profit for the entire year is $17,396,000.

Number of Meters	**2,640**	**24**
Installation	$1,980,000	$18,000
Electricity	$68,640	$624
Salary	$1,560,000	$14,182
Vehicle	$172,000	%1,564
Total Cost	**$4,132,000**	**$37,564**
Income	**$21,528,000**	**$195,709**
Profit	**$17,396,000**	**$158,145**
Real profit		**$41,184**

Table 6: Estimated Profit and Real Profit from Meters

The estimated Total Cost is $37,564, the estimated Income is $195,709, and the estimated Gross profit is $158,145. Our collected data shows that the parking spots are not always busy. During our observation we saw that there were only 1,374 occupied spaces vs. 810 vacant spaces.

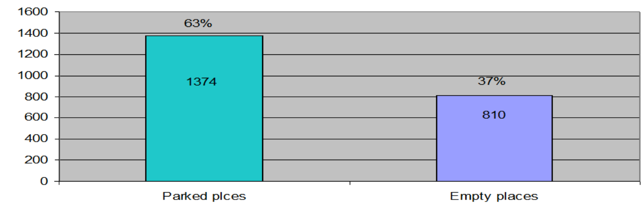


Table 7: Comparison of Occupied spaces vs. vacant spaces

Out of 1,374 spots only 884 spots showed money in the meters:

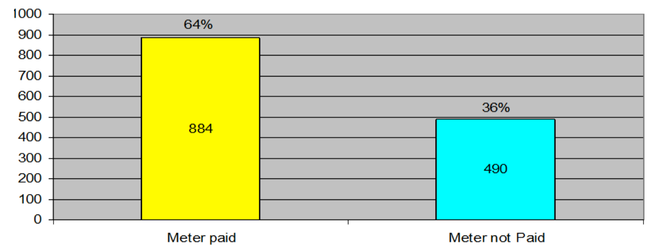


Table 8: Comparison of spots that were paid vs. the spots that weren't paid.

Based on the money collected during observation, the Real Income is $195,709, the real gross profit is $41,184, which is about 5 times less that estimated value based on the data provided by the city. The City still makes profit: the real profit from 2,649 meters is $569,800. So yes, it is profitable for the city of Stamford to maintain the meters in this part of the city.

VI. Importance of The Decision Analysis

The decision analysis shows that on-street parking meter revenue is better explained by real cost instead of nominal cost. Revenue per meter is much better than gross revenue. In terms of policy allegations it shows that enforcement pays- revenues increase with stricter enforcement. It also recommends that increasing fees instead of increasing fines is a more effective for bringing more revenues from on-street meters. Moreover, increasing fees will not raise revenues: an extreme increase in fines can change parking behavior and stop drivers from using on-street parking and attract them away from the free-parking shopping centers.

VII. Additional Material

While we were doing a research on the computer, we found an article about Baltimore computer developers who are going to use city data to build 'risk' app for motorists. This new smartphone app will help "drivers know the odds of receiving a ticket wherever they illegally park their car, run a red light or exceed the speed limit (Pala & Inanc, 2007) p.21."

The new app “gives you a threat rating. We can look at the history of citations and gauge the likelihood of getting a ticket (Pala & Inanc, 2007) p34.”

The authors of the new app plan to build paid mobile applications for iPhones and Android-powered phones and “to expand their coverage to other cities, including Portland, Ore., and San Francisco (Pala & Inanc, 2007) p.35.”

Whether web developers can use the city data to make applications that bring in revenue is still unknown.

VIII. CONCLUSION

On-street meters provide short-term parking for shoppers and other users of any town center. They are vital for life of any urban landscape, and their demand surpasses the supply. Violation of parking meter protocols is an illegal act (Slovic & Gregory, 1999; Verhoef, Nijkamp, & Rietveld, 1995). Half of all parking violations are around these on street parking meters. But there is little methodical information about parking meter behavior (Gur & Beimborn, 1984; Pala & Inanc, 2007; Weick, 1979).

This study provided some understanding into this activity. It is based on experience of one area of one city, Stamford, CT. However, we believe that the data are representative of most medium and even large cities in the U.S. The uniqueness of this study is in collective analysis of historical data, which provides views on costumers’ behavior over a long-term, with first hand survey of current behavior.

The initial guess based on the assumptions mentioned above was it is better for a customer to pay the meter. After analyzing the data collected, we also came to the conclusion that the decision of paying the meter is a better option for the customer. The main difference between the hypothecs and the results of the experiment is the expected value of not paying the meter. The expected value of the result is -$0.7725 and the expected value of the result is -$7.725 which is about ten times greater. This difference is due to the fact the actual probability of getting a ticket is much smaller than our original assumption.

Also for the city it is still profitable to have the parking meters in that area. Even though, there were some violations made, and the parking spaces weren’t always 100% occupied, the city still makes profit

REFERENCES

Fayyad, U. M., & Irani, K. B. (1992). On the handling of continuous-valued attributes in decision tree generation. *Machine learning, 8*(1), 87-102.

Gur, Y. J., & Beimborn, E. A. (1984). Analysis of parking in urban centers: equilibrium assignment approach. *Transportation Research Record*(957).

Kerley, R. (2007). Controlling urban car parking–an exemplar for public management? *International Journal of Public Sector Management, 20*(6), 519-530.

Pala, Z., & Inanc, N. (2007). *Smart parking applications using RFID technology.* Paper presented at the RFID Eurasia, 2007 1st Annual.

Ross, H. L. (1960). Traffic law violation: A folk crime. *Social Problems, 8*(3), 231-241.

Slovic, P., & Gregory, R. (1999). Risk analysis, decision analysis, and the social context for risk decision making *Decision Science and Technology* (pp. 353-365): Springer.

Verhoef, E., Nijkamp, P., & Rietveld, P. (1995). The economics of regulatory parking policies: the (im) possibilities of parking policies in traffic regulation. *Transportation Research Part A: Policy and Practice, 29*(2), 141-156.

Weick, K. E. (1979). *The social psychology of organizing*. Reading, MA: Addison-Wesley.