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EFFECTIVENESS OF DIFFERENTIATED PARKING PRICING – IMPLICATIONS FOR THEIR IMPLEMENTATION

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EFFECTIVENESS OF DIFFERENTIATED PARKING PRICING – IMPLICATIONS FOR THEIR IMPLEMENTATION

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ABSTRACT

Reducing traffic-related problems is an important problem that can be addressed by changes in travel behavior. Parking pricing is an effective tool as it affects car drivers with a direct charge. The influence on travel behavior is even higher if the charges are differentiated in place and/or time. A laboratory experiment with a heterogeneous sample (n = 79) examined effects of differentiated parking pricing schemes on understanding, acceptability and behavioral change intentions. The effect of odd and even numbers is also analyzed. The results show that difficulties are experienced in calculating the charges for high differentiated parking pricing schemes. Elderly were less able to respond properly and less flexible than young people in indicating how they would respond. Parking pricing schemes with odd numbers cause higher difficulties to calculate the charge. If people miscalculated, the deviations from the correct results are mostly more than €0.50. Further, the perceived effectiveness has a significant influence on the willingness of car drivers to adapt their mobility behavior. Recommendations for the implementation of parking pricing are derived from these findings.

Keywords: Parking pricing, user response, price differentiation, pricing structure

1. INTRODUCTION AND BACKGROUND

Every car driver faces parking when reaching a destination. For most car drivers, free parking constitutes a matter of course. But free parking will discourage users to consider alternative modes and will increase car use. And even if there are no charges for a parking space for the users, there will always be costs (Shoup, 1997). The costs of a typical downtown parking lot

amount for $20,000 to $50,000 per space (Nelson & Schrieber, 2012). Usually these costs are hidden in lower land values, higher housing and consumer prices. Pricing policies such as (dynamic) parking pricing appear to be a very effective tool to influence the users travel behavior. Several communities and cities already established smarter parking management as early adopters (e.g. San Francisco). Their results show that such a management can revitalize city centers, improve the customer experience, and reduce traffic and parking congestion (Nelson & Schrieber, 2012). Nevertheless, the major barrier to the wide implementation of this pricing strategy is still the lack of public and political acceptability (e.g. Bonsall et al., 2007; Jakobsson et al., 2000; Rienstra et al., 1999; Schlag & Teubel, 1997). The challenge is to design a scheme that is both acceptable to the public and effective in achieving more sustainable travel behavior.

The first-best pricing structure would be if parking lots in every street were priced differently every hour depending on the demand situation (e.g. Rouwendal & Verhoef, 2006). In practice, this would result in highly differentiated parking pricing schemes. Similar assumptions can be found concerning road pricing, where theory would say that "[...] dynamic variations in price might be used to fine-tune the demand hour-by-hour and even minute-by-minute [...]" (Bonsall et al., 2007). Many empirical studies demonstrate that such differentiated pricing schemes lack predictability and miss the target to achieve sustainable travel behavior (e.g. Bonsall et al., 2007, Francke & Kaniok, 2013). To obtain the desired effect on car drivers' behavior it will be necessary that they understand the charging system as well as accept it. Significant factors for the acceptance of a parking pricing scheme are the experienced effectiveness, personal outcome expectation, and the perceived fairness of the measure (e.g. Schlag, 2004).

On the other hand, if the parking pricing scheme is very simple and there is only one standard parking price, the car drivers' behavior cannot be influenced effectively. The objective to equalize the daily inner-city traffic demand will not be reached.

Moreover, parking charges have a greater effect than other out-of-pocket expenses that car drivers are facing. A parking charge of e.g. $1.00 per trip induces the same decrease in car use than a fuel price increase of $1.50 to $2.00 per trip (Litman, 2012). Compared to road pricing it also has an already higher acceptability and lower costs of implementation.

Besides the pricing scheme structure also the price structure has an influence on the response to pricing schemes as it influences the users' perception. Even numbers are easier to understand, to calculate and to memorize than odd numbers (e.g. Schenk, 2007; Diller, 2008).

This paper contributes to the growing body of research in this area by conducting a laboratory study that investigates responses to differentiated parking pricing schemes. It concentrates on the pricing scheme structure and the price structure itself. The paper aims to examine to what degree of pricing scheme differentiation users are able and motivated to deal with differentiated parking pricing schemes. It is hypothesized that with an increasing degree of differentiation the scheme comprehension decreases. The latency time will increase as well as the error rates when the degree of differentiation increases. Further, the presentation of the numbers (odd vs. even) has also an effect on users response. It is predicted that for the schemes with odd numbers the latency times and error rates are higher and the perceived comprehension and the confidence are lower than for even numbers. It is also hypothesized

that with higher perceived effectiveness of the parking pricing scheme, the behavioral adaptation is more likely.

In Section 2 the method of the study is presented. The third section describes the results, which are then discussed in Section 4. Also in Section 4, recommendations for the implementation of parking pricing are derived, limitations noted, and needs for further research discussed. In Section 5 conclusions are drawn.

2. METHODS

A computer-based laboratory study with a heterogeneous sample (n = 79) was conducted in January 2012. The participants were seated in front of a computer screen where all materials were presented. In the study each participant was presented with five hypothetical parking pricing schemes differing in the numbers of time bands and parking durations. The five parking pricing schemes had therefore different degrees of differentiation (see Table I). The schemes were partly based on the parking pricing scheme design of San Francisco. In San Francisco a dynamic parking pricing scheme is preliminarily implemented since 2010/2011. The prices per lot vary monthly depending on the actual traffic demand. They have four different time bands per day and the parking fees are charged in 30-minute increments (San Francisco Municipal Transportation Agency, 2011).

Participants were asked to calculate the charge that would occur for a certain parking duration that was given. The time of calculation was measured by the computer in seconds from the presentation of the parking pricing scheme to the answer was given.

Table I – Parking pricing schemes varying from low to high differentiation.

Pricing scheme	Low differentiation	Medium differentiation – even duration	Medium differentiation – odd duration	High differentiation – odd duration	High differentiation – odd prices
Number of time bands included	1	4	4	8	4
Parking duration (h)	7	7	4.5	4.5	7
Presentation of numbers	Even prices even duration	Even prices even duration	Even prices, odd duration	Even prices, odd duration	Odd prices, even duration
Charge (€)	21	20	11	17.10	13

Figure1 shows the parking pricing scheme for the medium differentiated pricing scheme with four time bands and an even parking duration of seven hours. To examine the effect of odd and even number presentation the two pricing schemes that are comparable and only differ in their number presentation are analyzed in more detail (Medium differentiation – even duration vs. High differentiation – odd prices).

For each of the five parking pricing schemes participants also made ratings on five-point numerical scales of comprehension of the pricing scheme, confidence in the charge estimate,

and difficulty in making the charge estimate. Subsequently, the randomly last selected parking pricing scheme was presented and the participants were asked to rate six statements about price complexity and fairness on a five-point Likert scales (1 – strongly disagree to 5 – strongly agree). Participants were also asked to rate on a five-point rating scale (1 – very unlikely to 5 – very likely) the following alternatives of how they intend to adapt their travel behavior if this parking pricing scheme is introduced: (1) continue driving into city center and pay charge; (2) avoid charged times; (3) car pool (more often); (4) use public transport (more often); (5) use bicycle or walk (more often).

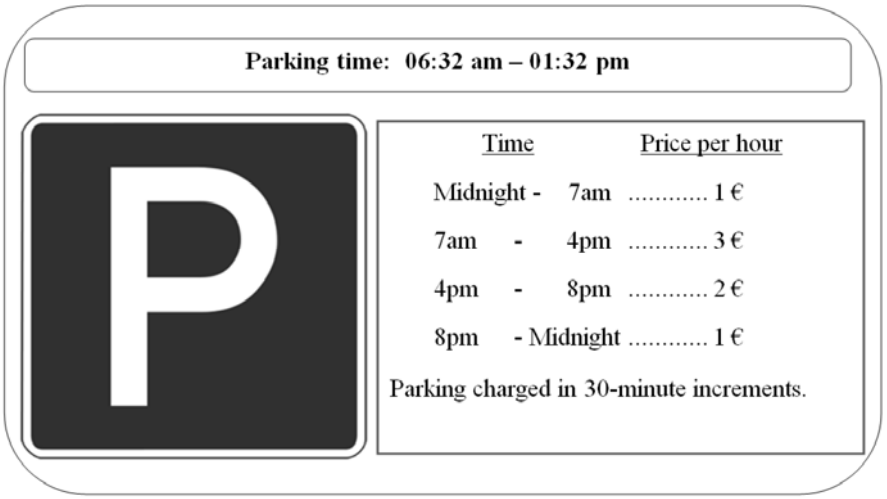

Figure 1 – Example of the task for the medium differentiated parking pricing scheme.

Table II – Sample descriptives.

Attribute	Sample
Sample size	79
Gender (%)	
Women	38.0
Age (%)	
under 30	39.2
30 – 39	12.7
40 – 49	15.2
50 – 59	16.5
over 60	16.5
Education (%)	
Secondary school	20.3
Grammar school	29.1
University degree	48.1
Net income per month (%)	
< 1500€	48.1
1500€ - 3499€	29.1
> 3500€	10,1
Missing	12.7

Socio-demographic data including age, gender, and education were also collected which are reported in Table II.

3. RESULTS

As hypothesized, latency time ($F(3.096, 222.931) = 15.81$, $p < .001$) and error rate ($F(4, 288) = 43.22$, $p < .001$) rose with increasing scheme complexity (see Figure 2). For medium and highly differentiated schemes, error rates were between 67% and 81%, which is primarily due to cognitive limitations.

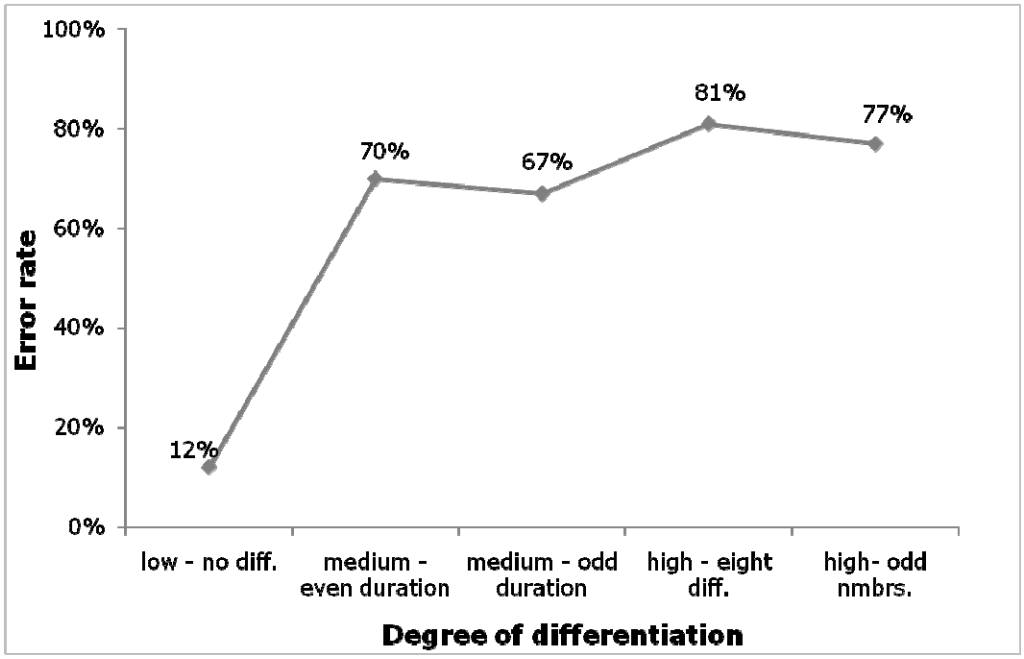

Figure 2 – Error rates of the presented parking pricing schemes.

There are subgroup differences concerning socio-demographic attributes. Elderly participants (>60 years) needed significantly more time to accomplish the tasks, $F(1, 71) = 20.56$, $p < .001$, and also made more errors than young participants (<30 years), $F(2.732, 415.304) = 12.38$, $p < .001$. For the highly differentiated scheme the elderly needed nearly twice as much time and made more than twice as many errors compared to the young participants.

A detailed analysis of the error rate showed that only 5% to 15% of the miscalculations are in the range of up to €0.50. That means that most of the incorrect answers deviated more than €0.50 from the correct result.

A parallel MANOVA on the ratings of comprehension, confidence, and difficulty showed that charge differentiation had a significant main effect, $F(3, 70) = 425.06$, $p < .001$. Univariate ANOVAs confirmed, that the more differentiated the pricing scheme the less participants comprehended, $F(3.408, 245.373) = 22.98$, $p < .001$, the less confident they were, $F(4, 288) = 41.55$, $p < .001$, and the more difficult they experienced the charge calculations, $F(3.541, 254.982) = 76.49$, $p < .001$ (see Table III).

Regarding acceptability, the more differentiated the pricing scheme was the lower was the acceptability of the participants (see Table III). Only the medium differentiated scheme with odd duration showed an exception and had the highest scores for acceptability. Subgroup with low and high acceptability were compared and showed no significant influence on the performance of the participants in terms of error rate or latency time.

Table III – Mean value (standard deviation) of ratings of comprehension, confidence, and difficulty related to degree of differentiation of parking pricing scheme.

Pricing scheme	Low differentiation	Medium differentiation – even duration	Medium differentiation – odd duration	High differentiation – odd duration	High differentiation – odd prices
Comprehen-sion[a]	3.88 (1.25)	3.16 (1.13)	2.97 (1.14)	2.58 (1.14)	2.67 (1.29)
Confidence[b]	4.19 (0.99)	3.34 (1.20)	3.22 (1.08)	2.96 (1.12)	2.92 (1.19)
Difficulty[c]	4.10 (.91)	3.05 (1.05)	2.85 (.94)	2.49 (.88)	2.19 (1.02)
Acceptability[d]	3.53 (1.18)	3.43 (1.28)	3.62 (1.30)	3.08 (1.24)	2.92 (1.32)

[a] Scale from 1 – very incomprehensible pricing scheme to 5 – very comprehensible pricing scheme.
[b] Scale from 1 – very unconfident to 5 – very confident.
[c] Scale from 1 – very difficult to 5 – very easy.
[d] Scale from 1 – very unacceptable to 5 – very acceptable.

Table IV – Comparison (mean value and standard deviation) of parking pricing schemes with odd and even number presentation for ratings of latency time, error rate, comprehension, confidence, and difficulty.

	Even numbers M (SD)	Odd numbers M (SD)	Significance
Error rate	.70 (.46)	.75 (.43)	$F(1,76) = .73$
Latency time (s)	106 (60)	133 (77)	$^{*} F(1,75) = 6.65$
Comprehension[a]	3.16 (1.12)	2.67 (1.29)	$^{***} F(1,75) = 12.87$
Confidence[b]	3.33 (1.19)	2.93 (1.17)	$^{***} F(1,75) = 15.27$
Difficulty[c]	3.04 (1.04)	2.20 (1.02)	$^{***} F(1,75) = 69.56$

* $p<.05$, ** $p<.01$, *** $p<.001$
[a] Scale from 1 – very incomprehensible pricing scheme to 5 – very comprehensible pricing scheme.
[b] Scale from 1 – very unconfident to 5 – very confident.
[c] Scale from 1 – very difficult to 5 – very easy.

ANOVAs showed that participants were faster in calculating, had a better comprehension and confidence and perceived a lower difficulty with even than with odd prices (see Table IV). The error rate showed no significant differences between both presentation forms of the prices.

Principal component analysis (*KMO* = 0.70, explained variance 64.3%) confirmed the two factors (1) flexibility in travel behavior adaptation (e.g. use public transport (more often) and (2) no behavioral adaptation (e.g. continue driving into city center and pay charge). The stated

behavioral intentions showed no significant differences between the five presented pricing schemes and therefore were combined. In order to test socio-demographic differences the then two standardized factor scores were submitted to ANOVAs. ANOVA showed that elderly (>60 years) were significantly less likely to adapt their travel behavior than young participants, $F(1, 42) = 22.77$, $p < .001$. Further, lower-income people (<€2,000 income) were more likely to adapt their travel behavior than higher-income people, $F(1, 67) = 8.30$, $p < .01$. Gender showed no significant influence but a trend with women being more flexible in their behavioral adaptation than men.

Results showed that the perceived effectiveness has a highly significant impact on the willingness of car drivers to adapt their mobility behavior ($F(4, 74)=3.473$, $p<.01$). The higher the effectiveness of the pricing scheme is perceived the more likely is the behavioral adaption, for example to shift the transport mode (see Figure 3).

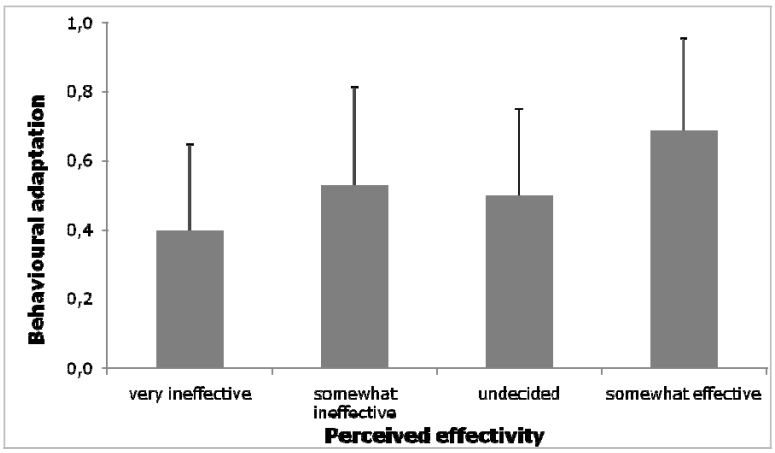

Figure 3 – Relationship between perceived effectiveness of the parking pricing scheme and behavioral adaptation.

4. DISCUSSION

The study confirmed that participants performed less well when charge differentiation of the parking pricing schemes was higher and when odd numbers were presented. The participants needed significantly longer and made more errors. These results are in line with previous studies (e.g. Bonsall et al., 2009; Francke & Kaniok, 2013, Rößger et al., 2008). When the schemes are high differentiated the cognitive load also increases and user comprehension and confidence decreases. More differentiated pricing schemes may therefore not induce the desired behavioral adaptations and may probably fail to be as effective as intended to be.

An analysis of subgroups showed that especially the elderly performed less well and this group might be therefore disadvantaged when such a differentiated parking pricing scheme is implemented. The more differentiated the schemes are the bigger was the gap between older and younger participants. The reason for the lower performance of the elderly is therefore not only because of problems dealing with a computer. In general elderly people need more time to accomplish tasks as previous studies already showed (e.g. Yordanova et al., 2003). Here, the simple communication and explanation in combination with aids are necessary.

Participants were also asked to state how they would adapt their behavior if such differentiated parking pricing schemes are implemented. The group could be separated in participants with flexible and participants with no behavioral adaptation. Younger and low-income persons are more likely to adapt their travel behavior if such differentiated parking pricing schemes are implemented. These people need reliable and affordable alternatives like attractive public transport systems.

Based on the findings, it can be recommended to differentiate only in two dimensions (rush hour and non-rush hour). The users should be provided with all information necessary to increase the scheme comprehension. It is further important to communicate and explain differentiated parking pricing and its objective before the implementation and when the scheme is in process in order to increase the perceived effectiveness (e.g. by positive examples from other cities). As odd numbers put users off they should be avoided in order not to add extra difficulties for the users. Finally the parking pricing scheme can only be one measure in a bunch that needs to be implemented to address all groups of society. Parking pricing is already widely accepted and used and users therefore know how parking pricing works in general. Based on this knowledge the implementation of differentiated parking pricing schemes is easier possible than for example road pricing schemes.

Using the parking meter is normally more an unpleasant than a welcomed duty. It should be designed as simple as possible to serve the user and as differentiated as required, in order to induce the behavioral adaptations.

It can be discussed that actually performing such a calculation seems redundant in a modern high-tech era. Nevertheless, users need an overview of all possibilities in order to compare the charges. This is necessary to decide whether a change of mobility habits is useful for the user. Therefore a higher comprehension leads to transparency and clarity which then leads to a higher acceptability. Only if users accept such policies they will induce the behavioral adaptations intended. Further, the more such pricing schemes are understood by the user, the higher the chances are that the change in mobility behavior will be sustained on a long-term basis.

To achieve an effective parking pricing system, political criteria also need to be considered. This includes measures like adapting legal regulations (e.g. the abolishment of minimum parking requirement for new buildings), keeping alternative transportation systems attractive and imposing appropriate fines.

The results of the study are limited by the small sample size which was slightly biased towards more highly educated and younger people. This was due to financial constraints and the surrounding of the university. Nevertheless a considerable amount of elderly people could be included in the sample in order to allow discussing the performance of this subgroup.

Further research is needed to analyze in more detail the impact of other inter-individual variables on understanding of and responses to differentiated parking pricing schemes, such as risk aversion or psychological reactance. It is further important to focus on the subgroups of the elderly to make sure that they will not be disadvantaged when such differentiated parking pricing schemes are widely implemented.

5. CONCLUSION

The paper focused on the structure of parking pricing schemes and how they can induce the desired behavioral adaptations. Once differentiated pricing schemes are understood and accepted, they can reduce external costs and relieve inner-city areas by fewer journeys or changes to alternative transport modes. Although the sample showed slight biases towards younger and higher educated people it allowed to analyze differences between subgroups in the performance and reaction towards differentiated parking pricing schemes. Based on the results of the analyses the following recommendations were derived: (1) two levels of differentiation seem sufficient to influence the users travel behavior, (2) odd numbers put users off and add too much difficulty on an already differentiated pricing scheme, (3) users need to be provided with all information necessary to increase the scheme comprehension, (4) the communication and explanation of differentiated parking pricing should emphasise its objective to enhance the perceived effectiveness and (5) differentiated parking pricing schemes are one measure in a bunch of measures to address all groups of society.

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