Costs and benefits of parking charges in residential suburbs

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SHORT SUMMARY

We present a model for evaluating social costs and benefits of street parking charges, and apply it to parking charges recently introduced in suburban residential areas in Stockholm. We also report the charges' effects on parking demand and occupancy rates. The analysis shows that the direct effect of the charges was a substantial welfare loss. If the revenues are used to lower distortionary taxes, however, the potential efficiency benefits of this second-order tax effect offsets the direct welfare loss, although treating parking as just another tax base may raise questions about fairness and equity. The model can also be used to calculate optimal parking charges and occupancy levels. Using parameters and demand functions estimated from the case study, we calculate optimal parking charges and occupancy levels, and show that the optimal charges are considerably lower than the introduced ones.

Keywords: parking charges; parking regulation; suburban streets; cost-benefit analysis.

1. INTRODUCTION

There has been a surge of interest in the economics of parking pricing and regulation in the last decade. There is still a dearth of empirical studies on parking pricing reforms, however, and in particular studies evaluating social costs and benefits of such reforms. This paper contributes to the literature by presenting developing a theoretical framework for social cost-benefit analysis of street parking charges, and applying it to an empirical case study where street parking charges were recently introduced in suburban residential areas in Stockholm. Effects of the parking charges on occumapncy levels are also described. Moreover, optimal parking charges and parking occupancy levels are calculated and compared to the actual ones.

Parking was long a neglected field in transportation research. However, in the last decade or two there has been a surge of interest in parking issues. The importance of the book by Shoup (2017, 2005) can hardly be overstated, with its emphatic and well underpinned arguments for socially efficient parking regulation and pricing. Since then, several streams of research have emerged, covering different aspects of parking policy. Inci (2015) provides a review of economic analyses of parking issues, such as garages' spatial monopoly power, employer-subsidized parking, the cost of distortive zoning regulations and several other issues.

Our framework is similar to Zakharenko (2016) in that parking demand is two-dimensional: whether to park in the study area, and for how long. We show that welfare-optimal parking charges must balance the costs of search traffic (search costs and external costs) against the loss of consumer surplus stemming from unused parking spaces. It follows that optimal occupancy rates varies between local contexts, with different turnover rates, search costs and demand relative to supply. It also follows that optimal parking charges are not zero even if search traffic do not generate external costs, and even if parking occupancy is less than 100 percent. This is because parked vehicles generate externalities on subsequently arriving parkers in the form of increased search time for a free parking space and increased walking time from the free parking space to the actual destination. Our framework allows us to simplify the derivation of Zakharenko's result that the optimal price for parking is proportional to the rate of arrival of new parkers, and inversely related to the square of the vacancy rate. Our main theoretical contribution is to show how these insights can be used for applied welfare analysis of a real parking pricing scheme.

The general conclusion is therefore that a parking pricing policy needs to be well designed and adapted to the local context to generate net social benefits. This is particularly important in suburban contexts, where there is typically less excess demand for parking, lower opportunity value of land less cruising for parking generating external effects especially through increased road congestion.

We also add to the literature by providing a welfare calculation of an large scale implementation of parking charges. There are only few studies computing welfare effects of parking charges. However, van Ommeren and Russo (2014) find that free parking induce a welfare loss of 10 percent of the resource value of the parking space and that a flat rate rather than a time-varying charge reduces the welfare gain 4 percent of the resource value. van Ommeren et al. (van Ommeren et al., 2021) (2021) provides a welfare calculation for Melbourne, based on Zakharenko's (2016) theoretical framework.

We find that parking demand (average occupancy) declined by around 25 percent when parking charges were introduced. This can be compared to the existing evidence on the cost sensitivity of parking demand has been published. In an early review paper, Marsden (2006) gives a range of price elasticities of parking demand from -0.6 to -0.1, with -0.3 being the most frequently cited value. Kelly and Clinch (2009) report an average value of -0.29 for parking frequency, with variations depending on weekday and time of day. A meta-analysis by Concas and Nayak (2012) reports an average elasticity of -0.39 (-0.86 for non-US countries). Madsen et al. (2013) point out that if estimates of price sensitivity do not control for variations in occupancy and hence search time, the estimates will tend to be deflated, since higher parking charges lead to lower occupancy and hence shorter search times, ceteris paribus. Taking this into account, they estimate a parking price elasticity of -0.7. Lehner and Peer (2019) conduct a meta-analysis of parking price elasticities, distinguishing between elasticities parking occupancy, dwell time and parking volume. The elasticities cited above refer to marginal variations of existing parking charges. Empirical evidence of the effects of introducing parking charges on previously unpriced residential streets seem to be scarce; we are not aware of any previous such studies. Krishnamurthy and Ngo (2020) analyse the effects of San Franscisco parking pricing reforms, showing that they have led to improved traffic flow, decreased emissions and increased transit ridership.

2. METHODOLOGY

Theory

We assume that there is a fixed and exogenous capacity at each parking location and that drivers have uniformly distributed desired stopping points. Let $p(t,h)$ be the parking charge for arrival time t and parking duration h, and let $D(t,h)$be the number of drivers who park at time t for a duration h. Let $s(t)$ be the parking search cost for a parker parking at time t. The consumer cost of parking consists of two parts: the parking search cost $s(t)$ and the parking price $p(t,h)$. Consider a small change of the price distribution $dp(t,h)$ and an associated change in the search cost distribution $ds(t)$. The total change in consumer surplus dCS is obtained by integrating over all arrival times and durations:

$$dCS = -\int\int D(t,h)ds(t)dtdh - \int\int D(t,h)dp(t,h)dtdh \qquad (1.)$$

In the paper, we show that this means that for distinct time intervals i with length H_i hours, the welfare change of a set of price changes dp_i giving associated changes in occupancy rates dq_i is

$$dW = \sum_i \left(p_i - \frac{cA_i}{r(1-q_i)^2}\right) H_i \frac{dq_i}{dp_i} dp_i. \qquad (2.)$$

and that the optimal parking charge per hour in time period i is

$$p_i^* = \frac{cA_i}{r(1-q_i)^2} \qquad (3.)$$

A_i is the number of arriving parkers, r is the parking space search rate per hour, c is the search cost per hour.

This is then applied in the Stockholm case study

3. RESULTS AND DISCUSSION

Data

In 2016, Stockholm decided to start charging for street parking in residential suburbs, where parking had previously been free. Parking occupancy rates were already considered to be high in some areas, and this problem was expected to grow worse since Stockholm tries to keep up with a fast-growing population by building lots of new residential housing. Moreover, if street parking is not priced, it is difficult to motivate that residential parking should be arranged off-street – in particular since parking spaces constitute a considerable cost in residential building projects. There was hence a clear logic underlying the parking reform. However, the pricing scheme that was introduced was rather crudely designed. All streets in relatively large areas were priced the same, regardless of their initial occupancy rates, and hence several areas became severely overpriced. The target occupancy rate was set to 85%, although the average occupancy rate was already well below that in most areas where parking charges were introduced. Moreover, the target occupancy rate was low considering the low turnover rate in residential suburbs (as pointed out in the theory section). Despite certain flaws in the design, the introduction of the charges on previously unpriced residential streets provides a valuable opportunity to study the effects on parking demand.

Parking occupancy was measured in 300 randomly selected blocks before and after the parking charges were introduced. On average, parking occupancy decreased by around 25 percent, but with large variation between different areas.

Results

The table below summarizes the empirical results.

	Area 4, multi-family housing areas	Area 4, single family housing areas	Area 4, other land uses	Area 5, multi-family housing areas	Area 5, single family housing areas
Hourly daytime parking charge (SEK/h)	10	10	10	5	5
Daytime occupancy before	85%	43%	23%	84%	23%
Daytime occupancy after	62%	22%	21%	73%	21%
Nighttime occupancy before	92%	44%	81%	92%	29%
Nighttime occupancy after	70%	21%	52%	*81%**	*27%**
Revenues (SEK/p-space)	74.46	25.80	60.00	43.85	12.56
Consumer surplus 1: demand loss and paid charges (SEK/ p-space)	-88.23	-38.70	-76.20	-47.12	-13.18
Daytime search time, before (seconds)	120	32	78	113	23
Daytime search time, after (seconds)	47	23	36	67	23
Consumer surplus 2: daytime search costs (SEK/p-space)	0.65	0.03	0.33	0.44	0.00
Nighttime search time, before (seconds)	225	32	95	225	25
Nighttime search time, after (seconds)	60	23	38	95	25
Consumer surplus 2: nighttime search costs (SEK/ p-space)	2.19	0.05	0.62	1.84	0.00
TOTAL BENEFITS (SEK/p-space)	**-10.9**	**-12.8**	**-15.2**	**-1.0**	**-0.6**
Number of parking spaces in the area	10 000	3 000	2 500	5 600	3 500
Total, MSEK per year	**-28.4**	**-10.0**	**-9.9**	**-1.5**	**-0.6**

The loss of consumer surplus stemming from fewer parking spaces being used is much larger than the benefit of reduced search costs, leading to a total welfare loss for society of around 50 MSEK/year.

The next table presents optimal parking charges:

	Area 4, multifamily housing areas	Area 4, single family housing areas	Area 5, multifamily housing areas	Area 5, single family housing areas
Optimal hourly daytime parking charge (SEK/h)	1.82	0.06	1.85	0.05
Optimal daytime occupancy	81%	43%	80%	23%
Optimal nighttime occupancy	88%	44%	88%	29%
Revenues (SEK/space)	17.62	0.31	17.74	0.14
Consumer surplus 1: demand loss and paid charges (SEK/space)	-18.08	-0.31	-18.19	-0.14
Optimal daytime search time (seconds)	94	32	90	23
Consumer surplus 2: daytime search costs (SEK/space)	0.26	0.00	0.23	0.00

Nighttime search time, after (seconds)	150	32	150	25
Consumer surplus 2: nighttime search costs (SEK/space)	1.11	0.00	1.11	0.00
TOTAL BENEFITS (SEK/space)	**0.9**	**0.0**	**0.9**	**0.0**
Number of parking spaces in the area	10 000	3 000	5 600	3 500
Total, MSEK per year	**2.39**	**0.00**	**1.30**	**0.00**

Optimal hourly charges turn out to be slightly below 2 SEK/hour in multi-family housing areas, and essentially zero in single family housing areas. Optimal occupancy rates vary between 80% and 88% in multi-family areas, and obviously stay at their initial level in single-family housing areas. The societal benefits resulting from the optimal flat daytime charge is around 4.7 MSEK/year.

4. CONCLUSIONS

Setting optimal street parking charges means balancing low search costs versus allowing existing parking spaces to be used by parkers. This paper presents a simple framework for evaluating the social benefits of a parking charge scheme, and applies it to the recently introduced parking charges in Stockholm's residential suburbs.

One of the insights from the framework is that the optimal occupancy rate will be higher in areas with long parking duration (low turnover rates), and hence the optimal parking charge lower, ceteris paribus. This means that optimal occupancy rates will typically be higher in residential suburbs than in city centers or shopping streets. This differs from the common practice to aim for the same, fixed occupancy rate in all areas.

As the case study shows, introducing too high parking charges can cause substantial welfare losses. The introduction of street parking charges in Stockholm's residential suburbs caused a welfare loss of around 50 MSEK/year, according to our calculations. In multi-family housing areas, we estimate the optimal flat daytime charge to slightly less than 2 SEK/hour, rather than the actual 10 SEK/hour (zone 4) and 5 SEK/hour (zone 5). In single-family housing areas, the optimal charge is essentially zero, since even the initial occupancy rates were so low.

The case study yields some interesting empirical observations. Parking demand is clearly cost sensitive, even in areas such as these where parking is dominated by residential parking. The estimated cost sensitivity is surprisingly consistent across most areas and times of day.

It is common that the price of street parking is too low, leading to long search times, external costs of search traffic and a pressure on planners and politicians to increase street parking supply, although allocating street space to parking tends to have a very high opportunity cost. Generally speaking, it is therefore often motivated to increase the price of parking. But it is also possible to put a *too* high price on parking, as shown in the case study presented here. That this risk is real is underlined by the fact that parking revenues are often a convenient source of revenue for a city, since it is at least partially levied on visitors from other constituencies. Just as with any price regulation, it is important to weigh its benefits against its social costs. Hopefully, the framework and lessons presented in this paper can help cities do that in a more efficient way.

REFERENCES

Concas, S., Nayak, N., 2012. A Meta-analysis of Parking Pricing Elasticity. Presented at the Transportation Research Board.

Kelly, J.A., Clinch, J.P., 2009. Temporal variance of revealed preference on-street parking price elasticity. Transp. Policy 16, 193–199. https://doi.org/10.1016/j.tranpol.2009.06.001

Krishnamurthy, C.K.B., Ngo, N.S., 2020. The effects of smart-parking on transit and traffic: Evidence from SFpark. J. Environ. Econ. Manag. 99, 102273. https://doi.org/10.1016/j.jeem.2019.102273

Lehner, S., Peer, S., 2019. The price elasticity of parking: A meta-analysis. Transp. Res. Part Policy Pract. 121, 177–191. https://doi.org/10.1016/j.tra.2019.01.014

Madsen, E., Mulalic, I., Pilegaard, N., 2013. A model for estimation of the demand for on-street parking (MPRA Paper No. 52301).

Marsden, G., 2006. The evidence base for parking policies—a review. Transp. Policy, Parking 13, 447–457. https://doi.org/10.1016/j.tranpol.2006.05.009

van Ommeren, J., McIvor, M., Mulalic, I., Inci, E., 2021. A novel methodology to estimate cruising for parking and related external costs. Transp. Res. Part B Methodol. 145, 247–269. https://doi.org/10.1016/j.trb.2020.12.005

Zakharenko, R., 2016. The time dimension of parking economics. Transp. Res. Part B Methodol. 91, 211–228. https://doi.org/10.1016/j.trb.2016.04.008