Modelling off-street parking prices with endogenous car ownership levels

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Introduction

In many cities around the world and especially in USA, off-street parking spots are normally bundled with the housing units, embedding essentially the parking cost in the rent, even if not utilized by the renter. However, in many cities off-street parking spots are treated as stand-alone units, allowing the market to determine their rental prices. Driven by this, off-street residential parking market can be viewed as a case where the market-clearing price is the result of a set of spatially varying characteristics, some of which have been the result of different policies. However, modelling of the pricing mechanism that governs such partial markets has received very low attention in the literature, mainly due to their unregulated nature. The current study aims to fill in that gap by modelling off-street parking rental prices for the city of Zurich in an attempt to comprehend the underlying pricing mechanism. A particular focus is given on addressing inherent shortcomings of the existing modelling approaches that can potentially arise and invalidate the findings. More specifically, the endogenous nature of local car ownership levels is treated by employing a two-stage least squares estimator and instrumenting it on a set of exogenous variables.

Residential Parking

Residential parking constitutes a relatively understudied, but nevertheless important aspect of parking provision. As residential parking we denote the provision of parking at the residence and it includes both public on-street and private off-street parking spaces. The impact of residential parking supply on car ownership has been examined (Seya, Nakamichi, and Yamagata 2016; Guo 2013) and the main findings show that it has substantial influence on the car ownership levels. Furthermore, another study (Weinberger, Seaman, and Johnson 2009) showed that the provision of residential off-street parking affects the overall commuting behavior, in aspects such as car ownership, and mode choice. In general, different policies are practiced concerning residential parking. For the case of on-street parking, the most common policy is to provide residents the right to park in restricted public zones through acquiring a residential parking permit (RPP), either freely available or for a nominal price (for a very low and spatially undifferentiated fee). Normally, the use of these restricted zones is unlimited for residents while non-residents can only park for a short time. However, this situation can give rise to a competition both within and between the two groups. In (Guo and McDonnell 2013), the authors investigate the possibility of charging residents for on-street parking in New York, a practice which is quite common in European countries. Their findings suggest that residents are willing to pay for an average $408 per year.

Zurich parking scheme

The existing parking provision in Zurich is the result of a combination of supply-focused and parking management policies put into practice over the last decades. In summary, pricing and time limitation

have been exploited as tools for parking management policy making, aiming at altering the demand for parking, especially during the day. In 1989 the city council decided to implement a parking restraint policy regarding the on-street parking in order to protect the residential areas from excessive traffic and emissions. In particular, on-street parking was divided into two categories, namely the blue and white zones (marked accordingly). White zones are aimed for shorter stays (up to 2-4 hours), normally upon a fee which varies by location. Blue zones are designated on-street parking spaces reserved for residents who upon paying a yearly fee of 300 Swiss francs (CHF) gain the right to park without any time limitations, whereas non-residents can remain parked at the same space for a maximum of an hour.

On the private parking spaces front, private off-street parking spaces exist, normally on-site, which are exploited commercially while there is no price regulation in place. The particularity of Zurich's parking policy lies on the fact that they incorporated maximum parking regulation in their ordinances relatively early (1989) while in the following ordinances (1996) and amendment (2010) both the maximum and minimum parking requirements were decreased further. More specifically, for each 120 square metres of residential floor area the minimum required parking space varies from 0.1 (in the city centre) to 0.7 (in the suburbs) while the maximum from 0.1 to 1.15. Essentially, the city council had decided to regulate the market in such a way to avoid giving rise to excessive parking supply, and thus to restrain car ownership and usage. Observational data suggest that in average their rental price is of about 150 CHF per month. It is worth pointing out the substantial price differentiation between the public and private public parking spaces when it comes to the residential parking case which can raise the question of how underpriced the public parking spaces are.

Case study

We utilize off-street parking advertisement rental data (obtained from web resources for the period of 2010-2014) where information about the monthly price, the location of the parking place, and the advertisement date is included. An overview of the rental prices along with their spatial distribution is given in Figure 1.

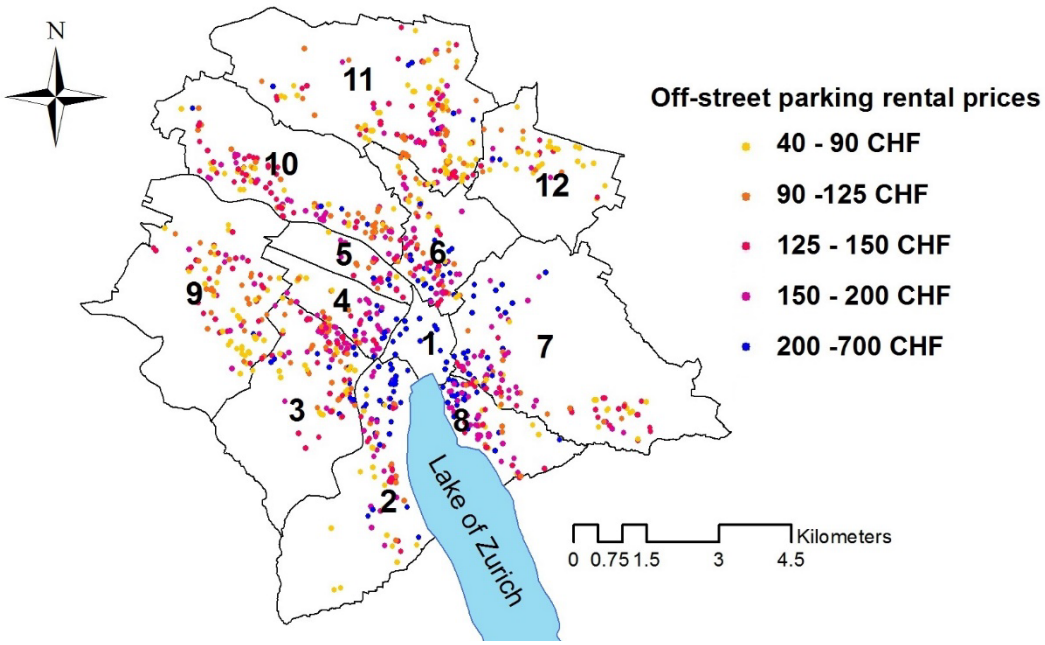

Figure 1: Study sample of the off-street parking asked prices per month in the city of Zurich

The employment of a semi-log specification as the functional form for our case is preferred for a number of reasons, such as better compliance with linear model assumptions (mitigation of heteroscedasticity issues), non-constant marginal effects, and lower sensitivity to extreme values (Wooldridge 2012). In addition, semi-log specification offers appealing parameters' interpretation allowing for a constant elasticity and semi-elasticity model.

Our qualitative hypothesis is that model results should be aligned with the empirical evidence and intuition concerning the determinants of the off-street rental price. In particular, we expect that parking supply variables should have a negative relation with price, reflecting the fact that as supply lowers, parking alternatives decrease and thus off-street parking prices increase. However, in cases of excessive on-site off-street supply a different relation is expected. On the demand side, we expect the relevant variables to be positively related with the rental price, as the result of more competition for the existing parking spaces. In addition, different income proxy variables need to be employed in order to account for its spatial variation, translating into higher willingness to pay for parking places. Last, car ownership is expected to exert a positive impact on the prices, while their apparent simultaneity in a local level can give to endogeneity issues. The model estimates are presented in the following table, including both the OLS (ordinary least squares) and the IV (instrumental variables) estimates.

In brief, the results validate our hypotheses about the impact of different variables on the rental prices. Interestingly, car ownership is not statistically significant when not instrumented while its sign is opposite to our expectations. In the case of the IV estimates, car ownership has a positive sign and is statistically significant at 5%, revealing an almost 20% elasticity value. Car ownership is instrumented on six variables, namely the square meters per residential unit (within 200 meters), the car accessibility, the average population size (within 300 meters), the share of one-person households (300 meters), the distance from the closest train station, and the slope. The supporting endogeneity tests validate the presence of endogeneity (Wu-Hausman), the choice of non-weak instruments (weak instruments test), and the instruments' exogeneity (Sargan).

Table 1: Hedonic model estimates

		OLS			IV	
Variable	Estimate	Std. Error	Sign.	Estimate	Std. Error	Sign.
(Intercept)	4.43	0.24	***	3.18	0.50	***
On-site private spots/ private spots within 200 meters	0.71	0.26	**	0.77	0.26	**
Unlimited public spots/ 120sqm. residential area (radius: 300m)	-0.31	0.12	*	-0.27	0.13	*
Limited public spots/ 120sqm. residential area (radius: 200m)	0.13	0.03	***	0.13	0.03	***
Residential use within 100m (%)	-0.43	0.10	***	-0.44	0.11	***
Public transport stops (radius 200 m.)	-0.003	0.002	.	-0.004	0.002	*
Retail floor area within 300m (%)	-0.63	0.17	***	-0.61	0.18	***
Ln(employment positions) (radius: 200 m)	0.12	0.02	***	0.14	0.02	***
Building's construction year [dummy: 1 if built after 1989]	0.18	0.06	**	0.18	0.06	***
On-site private spots/ 120 sqm floor area* dummy (1 if PBR<=2)	-0.09	0.03	**	-0.08	0.03	**
Private spots / 120 sqm floor area* dummy (1 if PBR<=0.75;radius: 200m)	-0.27	0.09	**	-0.33	0.09	***
Garage (dummy)	0.41	0.03	***	0.41	0.03	***
Distance from CBD [km]	-0.15	0.03	***	-0.19	0.04	***
Income proxies						
Distance from the closest kindergarten [km]	0.04	0.02	*	0.05	0.02	**
Lake view (dummy)	0.15	0.03	**	0.00	0.00	***
Residential sqm / household (radius: 200m.)	0.0013	0.0003	***	0.0012	0.0003	***
Year dummies						
Year 2011 (dummy)	0.05	0.03		0.05	0.03	
Year 2012 (dummy)	-0.02	0.03		-0.01	0.04	
Year 2013 (dummy)	0.08	0.03	*	0.09	0.04	*
Year 2014 (dummy)	0.18	0.04	***	0.17	0.04	***
Ln (Car ownership) [vehicles/1000 residents]	**-0.02**	**0.03**		**0.19**	**0.08**	*****
# of obs.					1005	
Adj. R-squared			0.474			0.443
AIC			768			-
Endogeneity tests						
Weak instruments						***
Wu-Hausman						**
Sargan						

Sign. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Conclusions

In summary, the results confirm our initial hypotheses and intuition about the determinants of market-clearing prices, while the impact of the different policies in place is present on the results. Notably, the provision of public on-street parking has a very high impact on the rental prices, reflecting that people

are willing to potentially cruise on a daily basis in the search of underpriced parking rather than pay a considerate amount of money for rent. This finding can give rise to certain discussions about whether or not the current public parking provision scheme in Zurich offers underpriced parking. Last, the results validate the importance of instrumenting the car ownership levels due to its endogenous nature with rental prices.

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