Parking in Residential Areas: A Stated Choice Analysis of Residents' Preferences

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Abstract
The study described in this paper concerns residents' preferences regarding parking in residential areas. An Internet-based questionnaire was administered to a sample of respondents who were invited to complete a stated choice experiment varying attributes of parking in residential areas. Their responses were analyzed using mixed multinomial logit models. The experiment shows that residents prefer free parking, close to their dwelling, a parking garage, exclusive use by residents, and guarded parking. More detailed analyses show that the influence of the parking characteristics on the preferences significantly depends on personal characteristics such as gender, age, level of education, and family composition. Significant standard deviations suggest heterogeneity among residents in their preferences, after controlling for these variables.

1. Introduction

In many European countries, including Belgium and the Netherlands, the number of cars and therefore the demand for parking space in residential environments is still increasing (e.g., Marsden, 2006; Van de Coevering *et al.*, 2008; Woldeamanuel, *et al.,* 2009). Increasingly more households own one or more cars and have to find space to park their cars. In residential environments, cars are parked at their own property or at one of the available private or public parking facilities in the vicinity of the households' dwellings. Because of the high demand for parking and the limited space in residential environments (most residential areas were designed with lower parking norms in mind), both municipalities and residents' committees are interested in parking preferences of residents. Based on these preferences optimal parking solutions for residential areas can be found (e.g., Althuisius *et al*, 2007; Borgers *et al*, 2008) and requirements of distinct user groups can be fulfilled (e.g., Broaddus, 2009). This holds for both urban and rural areas.

The study described in this paper aims at providing more insight into the preferences of residents regarding the parking situation in their neighborhood. Compared to previous research, this study focuses especially on various characteristics of parking solutions such as walking distance, parking costs and size of parking facility. The preferences are investigated using a stated choice experiment. (e.g., Wen, 2006; Borgers *et al*, 2008; Chalermpong *et al*, 2008).

The remainder of the paper is organized as follows. First, attention will be paid to the current residential parking situation and available insights regarding this issue. Next, the

adopted research approach is described followed by a description of the data collection. In the following section, the results of descriptive analyses are described. The model that is estimated on the stated choice data is discussed in the next section. The paper ends with the conclusion and suggestions for future research.

2. Parking in residential areas

In the past, little attention has been paid to residential parking. In many countries, the situation was not problematic; the supply of parking facilities was sufficient to accommodate the demand. This situation has changed dramatically (e.g., Broaddus, 2009). The literature describes three important developments that resulted into the current parking problems in residential areas (e.g., CROW, 2006). The first development concerns an increase in car ownership. For example, in the Netherlands the number of cars per household increased from 0.86 in 1995 to 1.05 in 2010. The second development concerns the availability of parking spaces in residential areas. The number of parking spaces is not increasing and many existing parking spaces are removed in favor of other land uses such as buildings or bus stops. This holds also for private areas where parking space is often sacrificed for an extension of the dwelling. The third development concerns the spill-over demand for parking from other areas where restricted parking policies have been introduced.

The intensity of parking problems strongly depends on the type and location of the area (e.g, Van de Coevering, 2008). In Europe, problems tend to be most intense in pre-war neighborhoods where in most cases planners did not take into account the presence of cars. The parking problem in newer neighborhoods is mainly caused by an increase in car ownership rates. In his literature review about the UK, Marsden (2006) mentioned an increase of 12 million cars by 2030 in the UK. Approximately a quarter of these cars have to be parked on-street. Cities already face several parking problems in residential areas such as high occupancy rates, long walking distances between parking and dwellings, and vandalism at parking facilities.

The increase of parking problems in residential areas causes a growing interest in the effects of residential parking on residents' behavior including the choice of home location and various travel choices such as travel mode and parking location. Previous studies show some evidence of existing relations between residential parking and residents' preferences. In 1993 Balcombe and York investigated the effects of parking measures in residential areas in England that experienced severe parking problems. They found that residents reduce car use because they are afraid of losing a close parking place. In addition, residents fear vandalism when the car is parked at some distance from their home. Empirical evidence on the importance of distance between home and parking, and security for the design of parking facilities in residential areas was also found by Stubbs (2002). He investigated the effect of the layout of parking in residential areas on residents' preferences. He found that if parking provision is not satisfactory regarding distance and security, residents are unlikely to purchase a house in the neighborhood. Borgers *et al* (2008) investigated residents' preferences for residential areas with restrained car access. In a stated choice experiment, residents were invited to evaluate hypothetical plans for residential neighborhoods. The plans were defined using different transport related characteristics including parking. The parking situation was represented by a combined variable describing distance from home to parking facility and presence of security. They found a negative effect of parking at distance from home on the residents' preferences. The negative effect is partly compensated by the presence of security.

The studies described in this section focus on two characteristics of the parking situation in residential areas: distance between parking and home location, and presence of security. To set up an appropriate parking policy for residential areas including guidelines for parking layout more characteristics related to the replacement of parking lots by parking garages could be considered (e.g., Bos *et al*, 2004); introduction of double use of parking facilities (e.g., Lamens *et al*, 2008); parking at some distance from home (e.g., Van Luipen *et al*, 2008); and introduction of parking costs for residents (e.g., Van Luipen & Bos, 2007).

3. Research approach

To better understand preferences of residents related to residential parking a stated choice experiment was developed which allows planners to gain insight into the effects of their planning measures on the attractiveness of residential parking from a user perspective (e.g. Ortúzar & Willumsen, 2001). To minimize the respondents' task and to make sure respondents compare alternatives, a stated choice approach was chosen over a stated preference approach. In the stated choice experiment, residents were asked to evaluate several hypothetical or imaginary parking situations in residential areas. The parking situations varied in terms of residents' contribution in parking costs, distance between dwelling and parking, type of parking, view on parking from dwelling, shared use of parking, size of parking, and guarding of parking. The selection is based on the literature review presented in section 2. Table 1 shows the selected characteristics of residential parking situations and the accompanying characteristic levels. The characteristic levels of the parking situation were systematically combined into residential parking alternatives using a 5^2*2^3 fractional factorial design. In total, 16 different parking situations were constructed and put randomly into 8 different choice tasks (see Figure 1). Each respondent was asked to choose between the two different residential parking alternatives the one they preferred. Respondents could also decide to choose none of the defined parking alternatives.

Table 1: *Characteristics and characteristic levels of residential parking situations*

Characteristics	*Characteristic levels*
Contribution in parking costs	No, 10 euro per month, 20 euro per month
Distance between dwelling and parking	50, 100, 150 meters
Type of parking	Parking terrain, parking garage
View on car from dwelling	No, Yes
Double use of parking	No, Yes
Size of parking	Small (up to 20 spaces), Big (more than 20 spaces)
Presence of guarding (video, personnel, etc.)	Yes, No

The experiment was implemented using an Internet-based questionnaire that also included questions about personal characteristics such as age, gender, education, household size, car availability, and residential location. The questionnaire also contained questions related to various characteristics of the residents' current parking situation: actual parking costs in the respondents' residential area; distance between parked car and respondents' dwelling; type of parking; view on the car from the respondents' dwelling; types of users of the parking; size of parking; and presence of guarding. In addition, respondents were asked to respond to some propositions regarding the current parking situation. The selection of issues is mainly based on the findings of Marsden (2006). The following propositions were included in the questionnaire:

- I often have to search for a free parking space;
- I often have to park my car at some distance of my dwelling;
- I feel safe when parking the car in the neighborhood;
- I think that the car might be damaged when parked in the neighborhood.

Respondents were asked to evaluate the propositions on a 5-points scale ranging from totally agree to totally disagree.

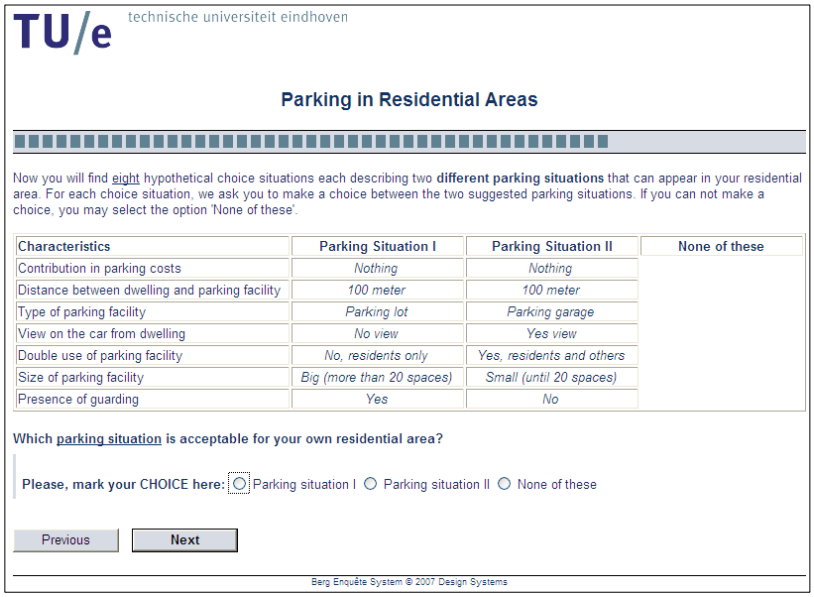

Figure 1: *Example of a stated choice situation*

4. Data collection

Respondents were recruited by distributing invitation cards in two villages in Belgium, Neerpelt and Overpelt with in total 30,000 inhabitants. The two villages were mainly selected because the authors are familiar with the structure and the parking situation of the villages. But also the ease of distributing the cards in a short time period was a reason to select the villages. Approximately 4000 invitation cards were randomly distributed across the two villages. The data of 410 residents could be used for further analyses. The personal characteristics and the local parking situation of the respondents are presented in Table 2.

Regarding the personal characteristics, it appears that for most characteristics there is an equal distribution across the distinguished characteristics levels. The characteristics family composition and residential location show a different distribution. In the case of family composition there is no explanation for the result. The distribution does not reflect the population in Belgium villages. The difference between the two residential locations can be explained by the difference in village size in combination with the numbers of distributed invitation cards that was related to the number of residents. These results imply that preferences should be weighted if the goal of the analyses/study would be to derive representative results for the population of these municipalities.

Looking to the residents' parking situation, it appears that the residents' current parking situation is not very problematic. An advantage of this finding is that the change of cognitive dissonance is likely to be absent in this study. Most respondents park the car on their own property at a short distance from their house and therefore do not have to pay for

parking, have a view on the parked car, and use non-guarded parking. This situation holds for many other villages and small cities in Belgium and other European countries. These findings have to be taken into account when interpreting the outcomes of the analyses.

Table 2: *Personal characteristics and parking situation of respondents (N=410)*

Characteristics	*Characteristic levels*	*Frequency*	*Percentage*
Gender	Male *(Female)*	241	58.8
Age	45 years and younger *(46 years and older)*	185	45.1
Education	Medium level *(High level)*	193	47.1
Car availability	1 car *(More than 1 car)*	177	43.2
Family composition	Family without children *(Family with children)*	288	70.2
Home location	Overpelt *(Neerpelt)*	140	34.1
Actual parking costs	Yes *(No)*	7	1.7
Distance to parking	50 meters or less *(More than 50 meters)*	348	84.9
Type of parking	Own property *(Other)*	290	70.7
View on parking	Yes *(No)*	306	74.6
Type of users	Nobody else *(Also other users)*	169	41.2
Size of parking	Own property *(Other)*	290	70.7
Presence of guarding	Yes *(No)*	13	3.2

In addition to describing their current parking situation, residents were also asked to respond to four propositions (see section 4). It appears that the majority of the residents (almost 75 percent) do not have to search often for a suitable parking around their dwelling. Still, almost 20 percent of the residents indicate that they have to search often for a free parking space, suggesting that capacity is less than ideal even for their own family. Similar results are obtained for the distance between parking and dwelling. In general, residents feel safe when parking their car. Approximately 75 agreed with the proposition 'I feel save when parking my car in the neighborhood'. The residents are less unanimous regarding the vandalism proposition. Almost 25 percent of the residents are afraid their car might be damaged or stolen when parked in the residential area. The reaction of approximately 20 percent of the residents is neutral (not agree/not disagree).

5. Choice of parking situation

In total 360 residents completed the stated choice experiment. The data of these residents was used to estimate a mixed multinomial logit model (ML model). The model describes the relationship between the probability of choosing a specific parking situation and the characteristics of the parking situation. ML-models allow random taste variation in the population of decision-makers (e.g., Train, 2003; Hess & Polak, 2004). In this study a normally distributed random component with mean 0.0 and standard deviation σ_k was added to each model parameter. For each resident, random numbers are drawn for each variable and individual choice probabilities are calculated. This is repeated R times and the probabilities of each alternative are averaged across the R drawings. In this study a Halton sequence of 1000 draws is used. Effect coding was used to represent the influence of the characteristics. Effect coding provides one way of using categorical predictor variables in various kinds of estimation models such as regression analysis. Effect coding uses only ones, zeros and minus ones to convey all of the necessary information on group membership. The software Limdep 4.0 (Green, 2007) is used to estimate the models. The results of the estimation of the model with main effects only are presented in Table 4.

With an R-square value of 0.342 the estimated model performs very well. In addition, the log-likelihood ratio statistic shows that the model outperforms the model with all parameters equal to zero (null model). The log-likelihood ratio statistic is equal to 2058.80 while the critical value for the test in the case of 20 degrees-of-freedom is equal to 31.41. Almost all characteristics influence the attractiveness of a parking situation in residential areas significantly (at the 95 percent confidence level) except for view on car and size of parking facility. The negative parameter for the constant indicates that in advance residents do not prefer one of the offered parking situations for their residential environment. Residents prefer a parking garage, exclusive use by residents, and guarding of parking. A positive parameter means that the characteristic level increases the total utility of the parking situation and in addition increases the probability that the parking situation will be chosen by the residents. Residents have a higher preference for parking close to their dwelling than for parking at some distance. Finally, residents do not want to pay for parking in their environment. Residents consider a monthly contribution to the parking costs as most important characteristic of the parking situation (with a maximum utility difference of 4.8011), at some distance followed by the distance between dwelling and parking (maximum utility difference of 1.2152). The assumption of heterogeneity among residents regarding the influence of the investigated characteristics is supported by significant standard deviations for almost all characteristic levels.

Table 4: *Model estimation results of the model with main effects only*

Characteristics	*Characteristic levels*	*Mean*[*]	*Std.dev.*[*]
Constant		**-2.2431**	**3.8414**
Contribution in parking costs	No	**2.4523**	**1.5000**
	10 euro per month	-0.1035	0.3635
	20 euro per month[**]	*-2.3488*	
Distance between dwelling and parking	50 meters	**0.5330**	**0.6929**
	100 meters	0.1492	**0.8323**
	150 meters	*-0.6822*	
Type of parking	Parking garage	**0.1898**	**0.6279**
	Parking terrain	*-0.1898*	
View on car from dwelling	Yes	0.1063	**0.3289**
	No	*-0.1063*	
Double use of parking	No	**0.1484**	**0.4836**
	Yes	*-0.1484*	
Size of parking	Big (more than 20 spaces)	-0.0235	0.0931
	Small (≤ 20 spaces)	*0.0235*	
Presence of guarding	No	**-0.1820**	**0.3902**
	Yes	*0.1820*	
Goodness of fit			
Log likelihood null model, LL_{null}		-3006.902	
Log likelihood optimal model, $LL_{optimal}$		-1977.500	
Log likelihood ratio statistic, $-2*(LL_{null}-LL_{optimal})$		2058.803	
Rho-square ML model		0.342	
Rho-square standard MNL model		0.102	

[*] **Bold:** significant at 95-percent confidence level ($\alpha < 0.05$)

[**] Base level calculated using effect coding

To get insight into the choice behavior of different groups of residents several MMNL models were estimated including average and contrast parameters. The *average parameters* represent the average effect of the characteristics of the parking information descriptions for both car drivers group 1 and group 2. The *contrast parameters* represent the differences between the distinguished groups of respondents. The contrast effects are calculated by multiplying the average effects with +1 (for group 1) and -1 (for group 2). First, residents were divided into groups based on their personal characteristics: gender, age, education, car availability, and family composition (see for groups Table 2). Table 5 presents the significant part-worth utilities per distinguished group at the 95 percent confidence level.

In the case of gender, it appears that the contrast parameters of one characteristic of the parking situation are significant. It appears that females prefer paid parking (until 10 euro per month) more than males. Looking at the age of the car drivers, it appears that younger residents do not like double use of parking facilities. In the case of education, the contrast parameters show that high educated residents prefer parking lots more than medium educated residents. The findings regarding the differences between the two car availability groups are a little bit surprising. The fact that none of the contrast parameters is significant indicates that despite differences in parking demand there are no differences in preferences regarding the parking characteristics between the two distinguished groups. It suggests that opinions about parking are quite fundamental and not primarily driven by own experiences. Looking at composition of the family, it appears that families without children prefer a view on their parked car more than families with children.

Table 5: *Overview of significant (≥ 95 percent interval) contrast parameters per aspect*

Aspect	*Characteristic and characteristic levels*	*Part-worth utility*	*Significance*
Gender	*Parking costs*		
Group 1: Male	No costs, group 1	+0.2941	0.026
Group 2: Female	No costs, group 2	-0.2941	
	10 Euro per month, group 1	-0.2667	0.003
	10 Euro per month, group 2	+0.2667	
Age	*Double use*		
Group 1: Older than 45 years	No, group 1	-0.1253	0.032
Group 2: 45 years and younger	No, group 2	+0.1253	
Education	*Type of parking*		
Group 1: Low and medium level	Parking lot, group 1	-0.1816	0.008
Group 2: High level	Parking lot, group 2	+0.1816	
Car availability	None		
Group 1: 1 car			
Group 2: More than 1 car			
Family composition	*View on car from dwelling*		
Group 1: Family without children	No, group 1	+0.1765	0.011
Group 2: Family with children	No, group 2	-0.1765	

6. Conclusions

The study described in this paper aims at providing more insight into residents' preferences regarding parking in residential areas. The descriptive analyses show that the residents included in the dataset are not facing any unusual parking situations or parking problems. The model analyses show that characteristics of the parking situation significantly influence residents' preferences for a specific parking situation. Only the view on the car and the size

of the parking facility seem to have no effect. The far most influential characteristic is parking costs, at some distance followed by the distance between parking and dwelling. The model also shows heterogeneity among residents regarding the influence of characteristics. For some personal characteristics (gender, age, education, and family composition) of the residents the influence is made more explicit by including contrast parameters in the model. The influence of personal characteristic is useful in the case the model is applied in certain residential areas with for example a majority of older or high educated residents. Interestingly, we did not find any differences between respondents owning one car and respondents who own more than one car, suggesting that parking preferences are generic and not context-dependent. Nevertheless, it seems useful to repeat the study in other areas with different parking situations and with different levels of parking problems.

For planners the results of this study are useful when setting up measures to decrease parking problems in certain neighborhoods. For example, to keep the attractiveness of parking in the neighborhood, the introduction of parking at a distance can be accompanied by the introduction of guarding at the parking. The insights can be incorporated in a market-based system as suggested by Broaddus (2009). To show the working of the model, several simulations using the estimated model with main effects only, were carried out. The results are presented in Table 6. The first scenario is used as the base situation: a residential area with a parking situation consisting of: small parking terrains, view from dwelling on the car, double use of parking facilities, no guarding, no parking costs, and a distance between dwelling and parking of 100 meters. After carrying out 1000 draws from the normal distribution for each random parameter (see Table 4), the residents assign an average utility of +0.0667 to this base situation. In scenario 1 a contribution to parking costs is implemented. It appears that the average utility decreases from +0.1038 to -2.4873. The scenarios 2 until 5 show additional changes in the other characteristics of the parking situation to compensate the decrease in average utility. It appears that the changes result only into a marginal increase of the average utility. The 'best' additional change concerns the introduction of parking garages.

Table 6: *Simulation with the parking preference model (main effects only)*

	Parking situations in residential areas					
Characteristics	*Base*	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*
Parking costs	No	**10 euro**	**10 euro**	**10 euro**	**10 euro**	**10 euro**
Distance to parking	100 m	100 m	100 m	100 m	100 m	**50 m**
Type of parking	terrain	terrain	terrain	terrain	**garage**	terrain
View from dwelling	Yes	Yes	Yes	Yes	Yes	Yes
Double use of parking	Yes	Yes	**No**	Yes	Yes	Yes
Size of parking	Small	Small	Small	Small	Small	Small
Presence of guarding	No	No	No	**Yes**	No	No
Average utility*	0.1038	-2.4873	-2.1677	-2.1416	-2.0782	-2.1067
Standard deviation	5.7812	4.2812	5.2484	3.5008	5.5370	4.1418

* *Based on 1000 draws from normal distributions;* **Bold: change of base situation**

The study can be extended by relating residents' preferences regarding parking with other choices residents face like the choice of buying a car (car ownership), the choice of travel mode, and the choice of residential location.

Finally, the study was carried out in two villages where the residents do not face any major parking problems. This situation holds for many villages in Belgium and the Netherlands. The question then is to what extent the results may be different if the respondents would be sampled from neighborhoods with major parking problems.

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