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The influence of parking facility characteristics on car drivers' departure time decisions

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Abstract

This paper describes a study of the influence of a destination's parking situation on car drivers' departure time choice. Three parking attributes are investigated in more detail: parking occupancy rate, parking tariff, and walking distance between parking and final destination. The descriptive analysis shows that the departure time of at least half of the car drivers is influenced by the investigated attributes. The model analysis shows that respondents tend not to adapt their departure time due to the parking attributes. In addition, it appears that both personal and trip characteristics influence the probability of adapting the departure time significantly.

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Keywords: Parking facility, Departure time, Multinomial logit

1. Introduction

Urban transport policies result into a continuously changing availability of components of the urban transportation network including roads and parking facilities. New roads are built and existing roads are transformed into, for example, bus lanes or pedestrian areas. The supply of parking changes continuously as well: new parking garages are opened while existing parking lots are reduced or closed. Other parking characteristics, such as parking tariffs, opening hours, and garage or lot design, often change. A destination's parking situation might affect

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travelers' decision process [e.g., 1, 2]. A travelers' decision process covers a variety of decisions such as when to leave home, where to go, what travel mode to use, and what route to follow.

Insights into the influence of a destination's parking situation on travelers' decision making process are still limited. In the past some studies tried to include a more detailed description of a destination's parking situation in destination, travel mode, or route choice models. For example, Ji *et al.* [3] presented a two-phased model for parking choice behavior in combination with route choice behavior. In their study, they found that five important factors affect car drivers' parking choice: walking distance from parking to final destination, type of parking facility (e.g., underground parking, multilayer parking, curb parking, and off-road parking), parking fee, available parking spaces, and driving time. In the model, they only include walking distance to final destination and number of available parking spaces. The model was specified in the context of commercial areas. It appears that both factors significantly affect parking choice behavior. Lam *et al.* [4] presented a time-dependent network equilibrium model that simultaneously considers a traveler's choice of departure time, route, parking location, and parking duration in road networks with multiple user classes and multiple parking facilities. They found that parking behavior is significantly affected by travel demand, walking distance, parking capacity, and parking charge. In a numerical study, Lam *et al.* [4] found some differences in the usage of parking facilities (duration, turnover, occupancy, and revenues) between static and time-dependent models. More research is needed to explore these differences. Van der Waerden [2] included a detailed description of destinations' parking situations in a combined travel model covering destination, travel mode, and parking / bicycle stall choice. He also found significant effects of parking attributes on travelers' destination, mode, and parking choices.

Until now limited attention has been paid to the role of a destination's parking situation on travelers' departure time choice. Van der Waerden *et al.* [5] investigated the influence of parking characteristics in case of car drivers arriving before 9:00 am or after 9:00 am. This study showed that time of arrival has a limited effect in the context of commuter parking. Only the effects of the presence of marks, vegetation, and maneuvering space were significant. It appeared that the presence of marks on the pavement is more important for car drivers arriving early (when places are still available). The same holds for the presence of maneuvering space. According to the effect of vegetation, car drivers arriving after 9:00 am prefer parking facilities with vegetation (and more space for illegal parking) more than car drivers arriving before 9:00 am. A more recent example concerns the study of Nurul Habib *et al.* [6] who investigated the effects of parking type choice on departure time choice based on car drivers' choice behavior in Montreal, Canada. They concluded that there is strong evidence that parking type choice influences car drivers' departure time decisions (for more details of this study see next section).

Fig. 1. Early bird parking in New York 2012

The aim of this study is to provide more insights into the influence of a destination's parking situation on the travelers' departure time choice. The relevance of insight into the influence of the parking situation on departure time decisions is retrieved from initiatives of practice where for example parking companies stimulate car drivers to change their arrival time by providing 'early bird' parking tariffs (see Figure 1). The remainder of the paper is organized as follows. First, some existing insights regarding characteristics that influence travelers' departure time decisions are presented. Next, the adopted research approach is outlined. This section is followed by a brief description of the data collection and the characteristics of the research sample. The analyses and the results of these analyses are presented in the following section. The paper ends with the conclusions and recommendations.

2. Literature review

In the past a variety of studies regarding travelers' departure time choice has been carried out. The studies focus on different viewpoints and applications such as time allocation and activity scheduling decisions [7]; time-of-day pricing program [8]; highway work zone delays [9]; flexible work schedules [10]; and residential location [11]. In addition, previous studies identified several influential variables as shown in the references below.

In the context of the current study, the following studies provide relevant information regarding usable variables. Ozbay & Yanmaz-Tuzel [8] developed a nested logit model for departure time choice and ownership of E-ZPass for electronic toll collection based on trip and traveler related variables. The trip related variables (travel time, toll paid, amount of early arrival time, amount of late arrival time, and distance traveled) are included in the lower nest, while the traveler related variables (age, gender, education level, and employment status) are included in the upper nest. It appeared that the combined departure time choice and E-ZPass ownership is highly influenced by individual and combined effects of toll level, travel time, income level, distance, desired arrival time, deviation of desired arrival time, age, gender, education level, and employment status. Jou *et al.* [12] applied the reference point hypothesis of prospect theory to commuters' departure time decision making. By doing this, they tried to better understand commuters' use of arrival time information in their daily departure time choice. The researchers postulated a segmented value function describing the actual arrival time and the gain or loss derived from the actual time relative to the preferred arrival time and working starting time. The study shows that 20 percent of commuters are likely to switch their departure time and most of commuters experience gain (arriving early but not too early). A more important conclusion is that commuters react asymmetrically to gains and losses. Sasic and Habib [13] investigated commuters' departure time choice using a discrete choice model with latent choice sets. They estimated a model for private car users and transit users. It appears that alternative specific constants, transportation level-of-service attributes (total costs, in-vehicle travel time, destination), work duration, and occupation type (general, manufacturing, professional) enter into the systematic utility function of alternative departure time choice for private car and transit users. He [10] developed a multinomial logit model to describe travelers' departure time choice. The independent variables cover various components such as (non)work-related activities, trip characteristics, household structure, demographic and socioeconomic status, job category and employment status, transport options, and perception. The model is estimated for both pre-peak and post peak period and the estimation shows significant influence of almost all included variables (non-work activities, travel distance, age, gender, Hispanic, race, household income, job category, employment status, region). Yang, *et al.* [11] developed a model for the joint choice of residential location, travel mode, and departure time. The model included house price, travel time, travel costs, and factors depicting the individual socio-economic characteristics. The model estimates show that the parameter for the nest of departure time is the biggest. It also appears that travelers (at least in Beijing) are more sensitive to transport levels of service in their choice of departure time than in their choice of travel mode. Finally, they found that time and cost elasticity's for am peak are larger than for other periods.

An important study in this context is the study of Nurul Habib *et al.* [6]. They developed a joint model of parking type choice, starting time choice, and activity duration to identify the effects of parking type choice on car drivers' starting time choice and activity duration. The Generalized Extreme Value (GEV) model includes socio-economic variables (age, household income, and job status), trip attributes (trip purpose, travel time, travel distance, and number of trips already made in the day), and two specific parking attributes (location and fare class). Location class covers four locations: street parking, outside parking lot, interior parking garage, and parking lot at transit station. Fare class includes free parking, charged parking, employer subsidized parking, residential parking, and parking at transit stations. Based on these two classes, in total 12 combinations are composed. It appears that activity scheduling decisions of car drivers are significantly influenced by parking choice where parking choice is being reflected in parking type and space availability.

As an addition to the study of Nurul Habib *et al.* [6], the current study pays more detailed attention to three attributes of the parking situation at a destination in combination with the travelers' trip purpose.

3. Research approach and data collection

To get more insight into the influence of the parking situation at a destination, the following research approach is adopted. Three different attributes of the parking situation are selected from the literature: occupancy rate, parking tariff, and walking time. It appears that these three attributes influence the travelers' decision regarding destination, travel mode, and parking facility the most. For each attribute the following question is formulated (Figure 2): *Do you ever adapt your departure time due to the occupation/parking tariff/walking time of a parking facility?* On a five points scale, the answer categories range from 'Never' to 'Always'. Respondents were asked to answer the question for the case that they visit a city center for four different travel purposes: work, shopping, social-recreation, and connecting train trip.

The questions were included in an online questionnaire. The questionnaire also included questions regarding the respondents' city center oriented visiting behavior (e.g., most common trip purpose, trip frequency, and travel time between home and city center) and personal characteristics (e.g., gender, age, and education).


universiteit hasselt

Onderzoek vertrektijd en parkeren

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Past u uw vertrektijd wel eens aan als gevolg van het parkeertarief voor de parkeergelegenheden rondom uw eindbestemming?

Het gaat om het aanpassen van de vertrektijd als u met de *auto* naar een bestemming reist.

	nooit	soms	regelmatig	vaak	altijd
Werkverplaatsing	○	○	○	○	○
Winkelverplaatsing	○	○	○	○	○
Sociaal-recreatieve verplaatsing	○	○	○	○	○
Aansluitende treinverplaatsing	○	○	○	○	○

Vorige Volgende

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Fig. 2. Part of the online questionnaire

Respondents were recruited using different approaches. Approximately 2000 invitation cards were distributed in and around the City of Hasselt, Belgium. Because of a low response rate, the members of the Eindhoven University's Parking (the Netherlands) panel were also invited to fill out the Internet-based questionnaire. In total, 380 respondents completed the questionnaire. The details of the respondents are presented in Table 1. It appears that for most included characteristics the distribution across distinguished categories is more or less equal. Only in the case of gender, it appears that slightly more males responded on the questionnaire. It is expected that the difference between the number of males and females does not influence the analyses suggested in this study. Regarding the trip characteristics, it appears that the respondents are more or less equally distributed across distinguished levels.

Table 1. Personal and trip characteristics of respondents

Characteristics	*Level*	*Frequency*	*Percentage*
Gender	Male	232	61.1
	Female	148	38.9
Age	Younger than 50 years	199	52.4
	50 years and older	181	47.8
Educational level	Medium	188	49.5
	High	192	50.5
Country of residence	Netherlands	196	51.6
	Belgium	184	48.4
Visit frequency	Infrequent	202	53.2
	Frequent	178	46.8
Travel time	<= 15 minutes	227	59.7
	> 15 minutes	153	40.3
Number of respondents		380	100.0

4. Descriptive analysis

The responses of the respondents on the questions regarding their adaption of departure time due to a destinations' parking situation are presented in Figures 3 to 5. First, it appears that more than half of the respondents indicate that they at least sometimes adapt their departure time due to the occupancy rates at the parking facilities. The differences between the included trip purposes are limited. In the case of trip purpose 'work', it looks that respondents tend to adapt their departure time more than in the case of the other trip purposes. In contrast, respondents tend to adapt their departure time less in the case of 'connecting train trip'. This last finding could be related to a larger margin in planned arrival time for connection train trips.

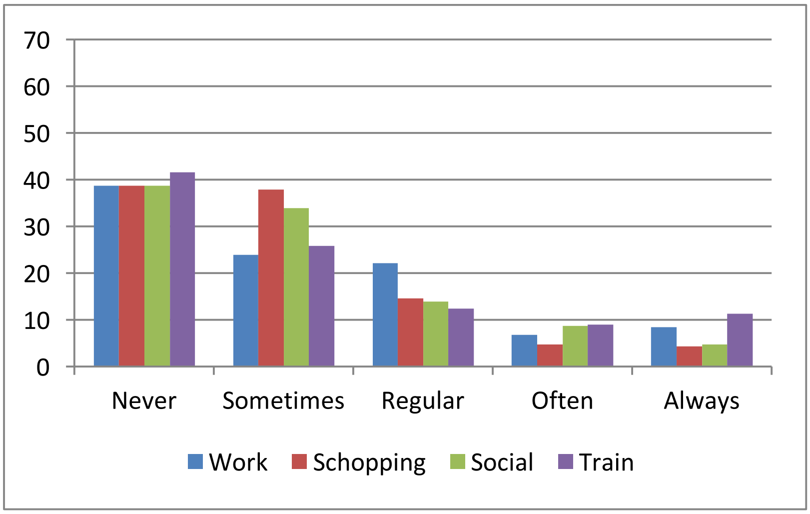

Fig. 3. Respondents' reactions on occupancy rates

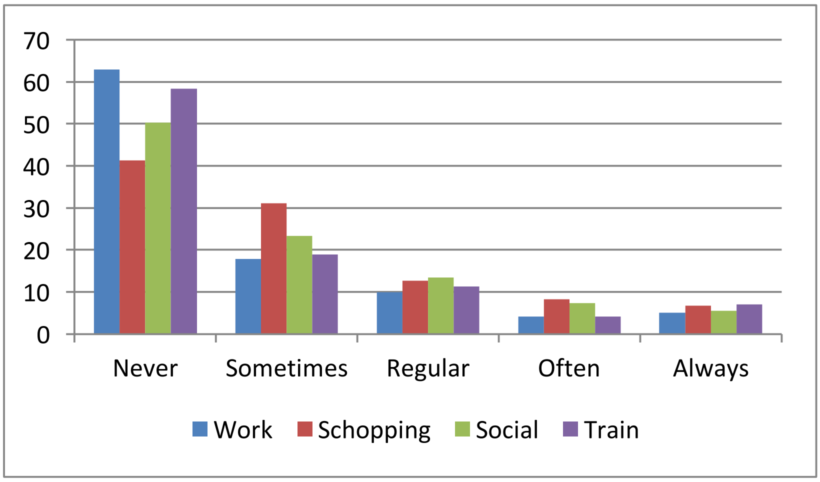

Fig. 4. Respondents' reactions on parking tariffs

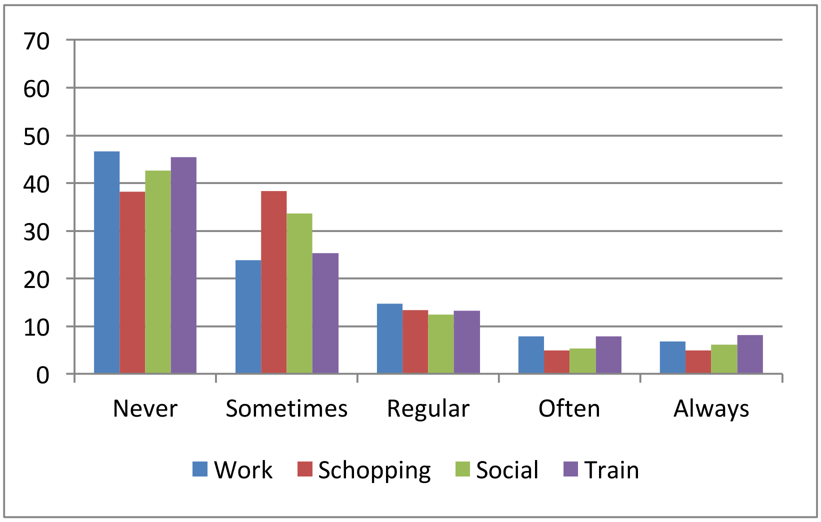

Fig. 5. Respondents' reactions on walking distance

In contrast to the previous finding, it appears that respondents adapt their departure time less when they look at a destination's parking tariffs (Figure 3). This is especially valid for work and connecting train trips. Almost 60 percent of the respondents never adapt their departure time due to the parking tariffs at the destination's parking facilities. The departure times of social and especially shopping trips are more sensitive to the parking tariffs. Looking at walking distance (Figure 4), it can be concluded that more than half of the respondents adapt their departure time due to the walking distance between a destination's parking facility and the respondent's final destination. Again, some small differences between the trip purposes exist.

In general, it appears that approximately half of the respondents indicated that they adapt their departure time in response to a destination's parking occupancy rate, parking tariff, and/or walking time between parking facility and final destination. There is no clear difference between the investigated trip purposes. To get a more comprehensive view, a model will be estimated with adaptation of departure time as dependent variable, and the destination's parking situation, trip purpose, and personal characteristics as independent variables.

5. Model analysis

The respondents' reactions are related to personal and trip characteristics using a standard multinomial logit model. The response levels are used as dependent variable, while the personal and trip characteristics form the independent variables. To represent the effect of these independent variables, effect coding is used. The answer category 'Never influenced by the indicated circumstances' was used as reference category. The econometric software Nlogit 5.0 is used to estimate the models [14].

Table 2. Estimation results, occupancy rate

Characteristics	Levels	Response category*			
		Always	Often	Regular	Sometimes
Constant		**-1.9135****	**-1.6984**	**-0.9064**	**-0.2525**
Purpose specific	Work	0.3040	-0.0027	**0.4038**	**-0.2000**
	Shopping	**-0.4836**	**-0.4001**	-0.0586	**0.2545**
	Social	-0.3494	0.2142	-0.0882	0.1454
Gender	Male	**-0.6178**	0.0118	**-0.1530**	0.0127
Age	50 years and older	**0.4493**	-0.0297	0.0634	-0.0512
Education	High	0.1259	0.0336	0.0671	**0.1460**
Country	Belgium	**0.9369**	**0.4113**	**0.5404**	0.0841
Frequency	Frequent	**0.4580**	**0.3077**	0.1199	0.0194
Travel time	> 15 minutes	**0.3919**	0.0574	0.0118	0.0700
Goodness-of-fit					
Log-likelihood optimal model			-2020.3198		
Log-likelihood null model			-2446.3456		
Log-likelihood ratio statistic			852.0516		
Chi-square test value (df=40)			55.76		
R-square			0.174		

* Reference category: 'Never influenced by'
** **Bold**: significant at 90-percent confidence level

The results of the model estimations are presented in Tables 2 to 4. It appears that all models outperform the null model (based on Log-likelihood ratio statistic tests) and represent the observed choice reasonably well (based on R-square values). Regarding the effect of the occupancy rate of a destinations' parking situation on the departure time decision, it appears that, in advance, respondents tend not to adapt their departure time (Table 2). The negative parameters of the constants show that the response categories 'Always', 'Often', 'Regular', and 'Sometimes' are less attractive than the (base) answer category 'Never'. For the other parameters, a positive sign indicates that the probability of the response category increase compared to the probability of the base category. For a negative parameter the opposite is valid. All included characteristics have at least one significant influence.

Regarding the effect of the parking tariff level of a destinations' parking situation on the departure time decision, the influences are more or less similar to the influences found for occupancy rate (Table 3). The negative parameters of the constants show again that the response categories 'Always', 'Often', 'Regular', and 'Sometimes' are less attractive than the answer category 'Never'. The effect is a little stronger than in the case of the occupancy rates. Almost all included characteristics have at least one significant influence, except education. Compared with the previous findings, here the effect of the constant for shopping is positive for the answer categories 'Always' and 'Often' instead of negative as in the case of occupancy rate.

Table 3. Estimation results, parking tariff

Characteristics	Levels	Response category*			
		Always	Often	Regular	Sometimes
Constant		**-2.2999**	**-2.2332**	**-1.6061**	**-0.8720**
Purpose specific	Work	**-0.3781**	**-0.4861**	**-0.3497**	**-0.4080**
	Shopping	**0.3692**	**0.5990**	**0.3209**	**0.5848**
	Social	-0.0538	0.3009	0.1801	0.0968
Gender	Male	**-0.3393**	-0.0622	0.0199	0.0635
Age	50 years and older	**0.7276**	-0.1953	**-0.1531**	-0.0923
Education	High	0.0430	0.0481	-0.0247	-0.1023
Country	Belgium	**0.5165**	-0.0485	**0.1887**	**0.3207**
Frequency	Frequent	**0.2257**	0.0296	-0.0155	0.0029
Travel time	> 15 minutes	**0.2091**	-0.0066	**-0.3190**	-0.0796
Goodness-of-fit					
Log-likelihood optimal model		-1843.4295			
Log-likelihood null model		-2446.3456			
Log-likelihood ratio statistic		1205.8322			
Chi-square test value (df=40)		55.76			
R-square		0.246			

* Reference category: 'Never influenced by'
** **Bold**: significant at 90-percent confidence level

Table 4. Estimation results, walking time

Characteristics	Levels	Response category*			
		Always	Often	Regular	Sometimes
Constant		**-1.9813**	**-1.9476**	**-1.2205**	**-0.3703**
Purpose specific	Work	-0.0105	0.1379	0.0148	**-0.2977**
	Shopping	-0.1374	-0.1171	0.1313	**0.3836**
	Social	-0.0523	-0.1816	-0.0702	0.1353
Gender	Male	**-0.7239**	-0.0578	-0.0836	-0.0846
Age	50 years and older	**0.5433**	-0.1717	0.0395	0.0541
Education	High	0.1754	**0.2680**	0.1138	**0.1658**
Country	Belgium	**0.6018**	**0.2997**	**0.5414**	**0.2140**
Frequency	Frequent	**0.3535**	0.1592	-0.1192	**-0.1218**
Travel time	> 15 minutes	**0.2407**	-0.0624	**-0.1877**	**-0.1677**
Goodness-of-fit					
Log-likelihood optimal model		-1960.4851			
Log-likelihood null model		-2446.3456			
Log-likelihood ratio statistic		971.7210			
Chi-square test value (df=40)		55.76			
R-square		0.199			

* Reference category: 'Never influenced by'
** **Bold**: significant at 90-percent confidence level

Regarding the effect of the walking distance between parking facility and final destination on the departure time decision, it also appears that, in advance, respondents tend not to adapt their departure time (Table 4). The negative parameters of the constants show that the response categories 'Always', 'Often', 'Regular', and 'Sometimes' are less attractive than the (base) answer category 'Never'. All included characteristics have at least one significant influence.

6. Conclusions

The study described in this paper aims to give some first insights into the relationship between a destination's parking situation and a car driver's departure time choice. Three specific attributes of the parking situation are selected to study in more detail: occupancy rate, parking tariff, and walking distance. Car drivers were invited to point out how often their departure was influenced by the attributes. The data of 380 respondents was included in the analyses. It appeared that the departure time of at least half of the respondents is influenced by the attributes. The largest influence is found for the occupancy rate, followed by the walking distance and the parking tariff. The model analyses shows that all included personal and trip characteristics influence the probability of departure time change significantly.

The findings of this study can be used by planners and decision makers to assess the effects of parking measures on not only the traditional travel related choices such as destination, travel mode, and parking choice but also departure time choices. The effect of the latter choice is strongly related to the demand for road infrastructure in general, and parking spaces in particular. Changes in a destination's parking situation in combination with the personal and trip characteristics of the main visitors group could change the demand for road infrastructure and parking spaces.

The current study was a first attempt to investigate the influence of a destination's parking situation on car drivers' departure time choice. In the future the research on this topic can be refined. For example, the parking measures could be described in more detail by including different levels of the attributes. Also a connection could be made to the daily activity schedule of car drivers.

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