A Conceptual Framework for Forecasting Car Driver’s On-Street Parking Decisions

Peer-reviewed author version

KHALIQ, Annum; VAN DER WAERDEN, Peter; JANSSENS, Davy & WETS, Geert (2018) A Conceptual Framework for Forecasting Car Driver’s On-Street Parking Decisions. In: Transportation Research Procedia, 37, p. 131-138.

DOI: 10.1016/j.trpro.2018.12.175
Handle: http://hdl.handle.net/1942/27174

Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

21st EURO Working Group on Transportation Meeting, EWGT 2018, 17-19 September 2018, Braunschweig, Germany

A Conceptual Framework for Forecasting Car Driver's On-Street Parking Decisions

Annum Khaliq[a,*], Peter van der Waerden[b], Davy Janssens[a], Geert Wets[a]

[a]*UHasselt-Hasselt University, IMOB, Agoralaan, 3590 Diepenbeek, Belgium*
[b]*Eindhoven University of Technology, Faculty of built Enviornment, PO Box 513, 5600 MB Eindhoven, The Netherlands*

Abstract

This paper describes a conceptual framework of a behavioral model, well able to predict the parking choice decision process of car drivers' while driving in a city center. The model assumes that parking choice decisions are mainly based on features associated to road conditions that a car driver faces while entering a street. A stated preference experiment was designed to collect respondents' preferences related to preferred parking facility. A set of hypothetical road conditions were presented in the form of choice tasks. The collected data is analyzed using mixed multinomial logit model. The results from the model estimation show that almost all the presented attributes such as parking costs, payment options, expected parking duration, speed limit, level of parking convenience, space availability and surrounding activities play a considerable role when determining car drivers' parking preferences. Moreover, the model highlights relatively important road related attributes which can induce search traffic. Therefore, cruising for parking can be reduced by avoiding certain road conditions, this information is valuable for the local authorities to design efficient parking policies.

Peer-review under responsibility of the scientific committee of the 21st EURO Working Group on Transportation Meeting.

Keywords: Parking policy evaluation; Forecasting model; On-street parking choice.

1. Introduction

High concentration of activities in city centers increase parking demand. Parking conditions affect the attractiveness of a destination Hensher and King (2001); Litman (2010). This indicates that parking plays an vital role in enhancing

* Corresponding author. Tel.: 32-11-269-111; fax: +32-11-269-199.
E-mail address: annum.kahliq@uhasselt.be

Peer-review under responsibility of the scientific committee of the 21st EURO Working Group on Transportation Meeting.

accessibility and live ability of urban areas. On-street parking is a major element of parking management Litman (2006); Marsden (2014). It affects the traffic situation of a city directly. The impact of on-street parking cannot be overlooked. It impacts in several ways such as traffic accidents, congestion, increase in pollution or increase in travel time due to cruising for parking Vasconcelos and Farias (2017). The traffic induced due to high level of cruising in urban areas is a critical issue for transport analysts and urban planners, as it impedes traffic movement along major routes Marshall (2014); van Ommeren (2012); Shoup (2006). Parking policy is an appropriate strategy to reduce parking search and tackle congestion problems. An efficient design of such a strategy requires knowledge about drivers' needs and decisions Ibeas et al. (2014). Therefore, it is necessary to investigate the underlying factors related to car drivers' on-street parking choices. This paper describes a conceptual framework proposed to forecast car drivers' on-street parking decisions considering road conditions of streets. This model is designed to evaluate parking decisions of car drivers' for short term trips to city center without explicitly considering any time pressure. In the past, parking choices of car drivers are studied considering a limited number of attributes, to reduce respondents biasness with respect to parking choices the approach of hierarchical information integration (HII) is employed. According to this approach, attributes of the choice alternatives are summarized into a high-order decision constructs. The respondents use the high order decision constructs to simplify the evaluation of multi-attribute alternatives Louviere (1984); Louviere, and Timmermans (1990). The basic objective is to observe car drivers' responses to multi-attribute alternatives and identify their parking decisions with respect to road conditions. The model is able to acknowledge relevant road conditions that contribute to cruising for parking, this can help in identifying how cruising can be minimized. Several studies exist in the literature that investigated car drivers' parking choices. Studies that investigated off-street parking include Axhausen and Polak (1991); Miller (1993); Van der Waerden and Oppewal (1995); Golias et al. (2002); Hensher and King (2001); Bonsall and Palmer (2004); Hess and Polak (2004). A study related to hierarchy of parking models was prepared by Young and Taylor (1991); Young (2008). It included model categories based on their purpose of use such as parking design models, parking search models, parking choice models, parking allocation models and parking interaction models. Thompson and Richardson (1998) presented a model to represent the parking search behavior of motorists using behavioral modelling framework. Arnott and Rowse (1999) presented a model of parking congestion focusing on drivers' search for a vacant parking space. Existing literature focus on models explaining off-street and on-street parking choices of car drivers, but none of the studies aid in forecasting car drivers' parking decisions keeping in view the road conditions of streets which is highlighted in this paper. This paper is organized as follows. Section 2 discusses related work. Conceptual frameworks is provided in section 3. Section 4 presents the methodology for conducting the research. Analysis and interpretation of the model output is explained in detail in section 4. While conclusions are presented in section 5.

2. Related work

Parking has been investigated in the literature to assess the impact of parking policy, therefore the information about modelling the user's behaviour to park a car is limited Belloche (2015). Several parking choice models have been developed in the past. Most of these models were related to off-street parking choice. Limited attention has been paid to car drivers' on-street parking choice behavior Khaliq et al. (2018). Most of these studies indicate that 'walking time' and 'parking costs' are the main contributing factors of the cruising behaviour in the context of both on-street and off-street parking. Stated choice approach has been enormously used to determine parking choices. Some researchers employed other techniques to model parking choices such as possibility theory has been used to investigate car drivers' parking choice behaviour with respect to different parking policies Ottomanelli et al. (2011). Similarly, Probit-User Equilibrium type traffic assignment model has been used to study congested road network and parking supply Bifulco (1993). Traffic assignment or network based simulation models, agent-based parking simulation model include Arnott and Rowse (1999); Leephakpreeda (2007); Benenson et al. (2008) ; Gallo et al. (2011); Waraich et al. (2012); Steenberghen et al. (2012); Guo et al. (2013).

Existing parking literature indicates that the use of stated choice approach to study car drivers' on-street parking choice decisions is limited. Various time related, price related and socio-demographic factors that influence car drivers' on-street parking search such as walking distance between parking and home, parking type, travel time, parking fee visibility of the car, motorized traffic in residential street, vehicle age, and security have been investigated using stated choice approach Brooke et al. (2014); Ibeas et al. (2014); Chaniotakis and Pel (2015); Pel and Chaniotakis (2017). Findings of all these studies show that major factors affecting choice of a parking space are parking cost and walking distance to destination, but all of these studies focused to investigate parking choices with respect to time (e.g. access time, search time, egress time, hours of operation, duration of parking, car availability), trip (e.g. parking duration, travel duration, parking time restriction), personal (e.g. income, gender) and parking related (e.g. expected illegal parking fine, occupancy rate, type of parking, willingness to pay for parking) characteristics. Discrete choice models have been traditionally used to describe an individual's choice of one option from a finite set of options Ortúzar and Willumsen (2001). These models assume that the decision makers try to maximize their utility (gain or profit) from the several alternatives offered Train (2003). The major advantage of using discrete choice models is that it measures preferences along with choices however, the percentage/ranking/order of the choice cannot be obtainedThis study investigates the effect of road conditions such as surrounding activities, speed limit and average number of parking spaces per 100m on car driver's parking decisions.

3. Conceptual background

In order to understand parking choices comprehensively, it is essential to have more insight into the reactions of car drivers who are facing certain road conditions in a street. In particular, we are interested in identifying the road conditions that people prefer when driving around looking for suitable parking place. In this research, we consider road attributes such as speed limit and surrounding activities as factors influencing parking decisions. This approach clarifies which conditions induce search traffic. The aim is to provide a strong and empirical evidence regarding car drivers' on-street parking decisions so that parking policies can be framed in accordance with car drivers' behavior, which can reduce number of cars cruising for parking. In the present study, we try to conceptualize when car drivers are driving towards their destination they continuously enter streets and in each street they look for parking opportunities, keeping in view the existing road conditions. It is assumed that all car drivers have three parking options available; either they will park on-street, park in a (off-street) garage, or continue to search for another parking alternative. Based on these assumptions prediction of car drivers' on-street parking choices can be conceptualized using the following framework (Fig.1.). This framework is more detailed in the section of research design.

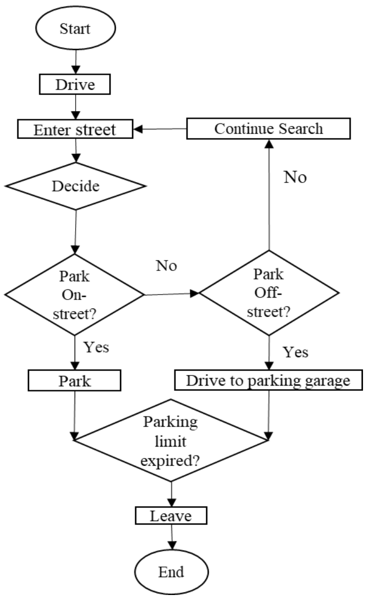
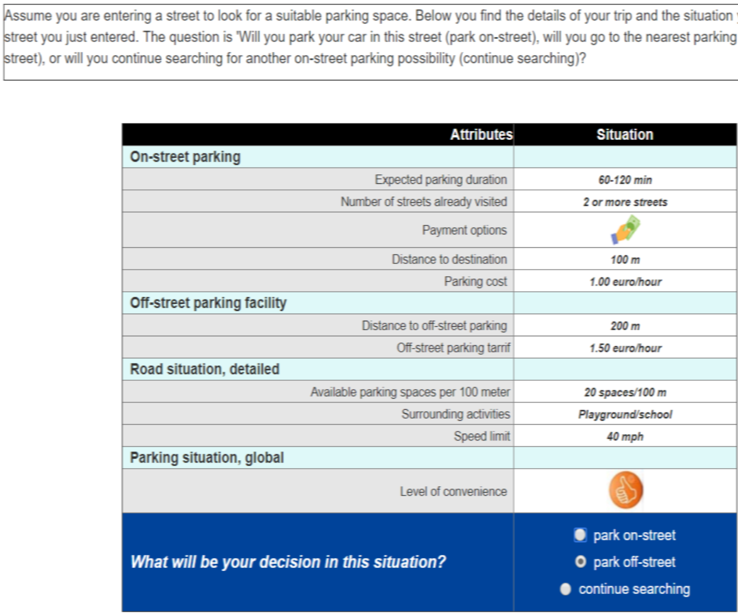


Fig.1. Conceptual framework for predicting car drivers' on-street parking choice.

4. Methodology

A stated choice experiment using basic principles of hierarchical information integration (HII) is designed to investigate car drivers' on-street parking decisions. The major focus of the above mentioned studies was to investigate a limited set of factors related to the parking context as the traditional stated choice experiments can handle only a limited number of attributes. Therefore, the integrated hierarchical information integration (HII) approach has been employed to investigate the effect of a larger set of parking and street related attributes on parking decisions. This large set of parking related attributes enhance the possibilities for the local authorities to design parking policies efficient enough to cater the problems related to on-street parking such as illegal parking and double parking Arnott (2006). Hypothetical street situations are presented (as choice tasks) and for each situation the respondents are asked to indicate their choice (park on-street, park in a parking garage, continue search) (shown in Fig.2.).


Assume you are entering a street to look for a suitable parking space. Below you find the details of your trip and the situation you face in the street you just entered. The question is 'Will you park your car in this street (park on-street), will you go to the nearest parking garage (park off-street), or will you continue searching for another on-street parking possibility (continue searching)?

Attributes	Situation
On-street parking	
Expected parking duration	*60-120 min*
Number of streets already visited	*2 or more streets*
Payment options	
Distance to destination	*100 m*
Parking cost	*1.00 euro/hour*
Off-street parking facility	
Distance to off-street parking	*200 m*
Off-street parking tarrif	*1.50 euro/hour*
Road situation, detailed	
Available parking spaces per 100 meter	*20 spaces/100 m*
Surrounding activities	*Playground/school*
Speed limit	*40 mph*
Parking situation, global	
Level of convenience	
What will be your decision in this situation?	park on-street park off-street continue searching

Fig. 2. Example of Choice task explaning road conditions.

The designed choice tasks were presented in an online questionnaire. The respondents were asked to assume that he/she is driving from his/her home to a destination (generic) located in the inner city. While driving he/she enters a certain street segment to search for a suitable parking space (see Fig.2.). The choice tasks were designed using a 3^{11} fractional factorial design. Road conditions are considered on 27 possibilities for 3 attributes the result indicate that these attributes do have an impact on parking choice. The adopted design consisted of 27 profiles assuming that only main effects are considered in this experiment. The attribute levels were defined keeping in view the literature and common practice in Belgium. The first five attributes are related to on-street parking in general, and include on-street parking costs, walking distance between parking location and final destination, expected parking duration (the length of time expected by the driver to park the car), modes of payment available for paying on-street parking costs, and the number of streets visited by the driver before entering the street segment. The other two attributes are related to the closest off-street parking facility: off-street parking tariffs and walking distance between off-street parking facility and final destination. The attributes 'Level of parking convenience' depict an overall level of convenience provided by street segment. Time of day is not included in the task. In addition, parking duration is also included as a replacement for time limit in the task. In this approach, attribute number of parking spaces per 100 meter represent supply. The data was collected using PanelClix (www.panelclix.be) to get the desired sample size characteristics. A well balanced sample (containing respondents from all categories of age, income, gender and education) was obtained by inviting Belgian members of the panel to fill in the questionnaire. In total, 548 responses were collected. The collected data is analyzed using Multinomial Logit Model, which is detailed in the next section.

5. Analysis & Interpretation

The car drivers' choices are analyzed using the Mixed Multinomial Logit (MMNL) model. In contrast to standard Multinomial Logit (MNL) models, MMNL models allow for random taste variation in the population of decision makers and can derive probabilities from utility maximization Hess and Polak (2009). NLOGIT version 5 is used to estimate the model. The choices of car drivers' (park on-street, park off-street, and continue searching) are used as dependent attribute. The alternative 'Continue searching' was used as base alternative. In this study, effect coding is used to represent all effects of the attribute levels. The coding scheme used in the model estimation is presented in Table 1. The results of model estimation process are presented in Table 2.

Table 1. Attributes and attribute levels with corresponding coding scheme.

Attributes	Levels	Coding (effect coding)
Payment options	Cash	1 0
	Cash-credit	0 1
	Cash-credit-phone	-1-1
Distance Off-Street	100 meter	0 1
	200 meter	1 0
	300 meter	-1-1
Off-street tariff	0.50 euro	1 0
	1.50 euro	0 1
	2.50 euro	-1-1
Streets visited	None	0 1
	One	1 0
	2 or more	-1-1
Expected duration	> 120 minutes	1 0
	60-120 minutes	-1-1
	< 60 minutes	0 1
Parking costs	Free	1 0
	1.00 euro/hour	-1-1
	2.00 euro/hour	0 1
Distance destination	100 meter	0 1
	200 meter	1 0
	300 meter	-1-1
Parking situation	Low	1 0
	Medium	-1-1
	High	0 1
Road Condition	Low	1 0
	Medium	-1-1
	High	0 1
Activities	Houses	1 0
	Shops	0 1
	Play garden	-1-1
Parking space/100 meter	10 space	-1-1
	15 spaces	0 1
	20 spaces	1 0
Speed limit	20 km/hour	0 1
	40 km/hour	1 0
	60 km/hour	-1-1

Table 2. Estimation results from Mixed Logit model.

Alternative	Attributes	Level values	Mean	Standard deviation
On-street parking facility				
	Intercept		2.77385***	3.07422***
	(On-street) Parking cost	Free	1.55806***	1.09904***
		1.00 euro/hour	-3.15805	

		2.00 euro/hour	-1.59999***	
	Distance between parking location and destination	100m	0.20121	1.13564***
		200m	0.28124	
		300m	-0.29656	
	Expected Parking duration	Less than 60 min	0.03839	
		60-120 min	-0.25817	
		More than 120 min	-0.29656	
	Payment options	Cash,	-0.10714	
		Cash & Bankcard,	0.35464*	
		Cash, Bankcard, Smartphone	0.46178	
	Number of streets already visited	No streets	0.29692	1.15202***
		1 street	-0.13784	
		2 or more streets	-0.43476	
		Off-street parking facility		
PARK ON-STREET	Distance to off-street parking place	100m	0.10077	0.74816**
		200m	-0.14376	
		300m	-0.24453	
	Off-street parking tariff	0.50 euro/hour	-0.10770	2.01924***
		1.50 euro/hour	-0.37447*	
		2.50 euro/hour	-0.26677	
		Road Conditions		
	Average available parking spaces per 100meter	10 spaces/100 m	-0.52413	0.93625*
		15 spaces/100 m	0.30516	
		20 spaces/100 m	-0.21897	
	Surrounding activities	House	-0.39191	0.61962
		Shopping	0.46229	
		Playground/school	0.8542	
	Speed limit	20 km/h	-0.15417	1.31148***
		40 km/h	0.46229	
		60 km/h*	0.61646	
		Decision Constructs		
	Level of convenience for parking situation	Low	-0.82565***	1.05356**
		Medium	1.57389	
		High	0.74824***	
		On-street parking facility		
	Intercept		2.09644***	2.96822***
	On-street parking cost	Free	-0.70435***	0.02018
		1 euro/ hour	1.18601	
		2 euro/ hour	0.48166**	
	Payment options	Cash,	0.12539	
		Cash & Bankcard,	0.06755	
		Cash, Bankcard, Smartphone	-0.05784	
	Number of streets already visited	No streets	0.02897	0.38845
		1 street	-0.16049	
		2 or more streets	-0.18946	
	Expected Parking duration	Less than 60 min	-0.06795	
		60-120 min	-0.41628-	
		More than 120 min	0.48423**	
	Distance between parking location and destination	100m	0.19765	0.17766
		200m	-0.08026	
		300m	-0.27791	
		Off-Street parking facility		
PARK OFF-STREET	Distance to off-street parking place	100m	0.12721	0.19872
		200m	0.18992	
		300m	0.06271	
	Off-street parking tariff	0.5 euro/hour	1.59541***	1.23116***
		1.5 euro/hour	-0.0616	
		2.5 euro/hour	-1.65705	
		Road Conditions		
	Surrounding activities	House	0.58592*	2.00028***
		Shopping	0.21092	
		Playground/school	0.375	
	Speed limit	20km/h	-0.24064	1.14453***
		40km/h	0.35574	
		60km/h	0.59638	

Average available parking spaces per 100meter	10 spaces/100 m	0.12982	1.22117***
	15 spaces/100 m	0.06237	
	20 spaces/100 m	0.19219	
	Decision Constructs		
Level of convenience for parking situation	Low	-0.1376	1.94336***
	Medium	0.267	
	High	0.4041	
Goodness-of-fit			
Log-likelihood of the null model, LL(0)	-2098.1977		
Log-likelihood of the optimal model,	-2416.9470		
LL(B)	637		
LRS=-2[LL(0)-LL(B)]	0.2879		
McFadden's Rho-Square	0.2770		
McFadden's adjusted Rho-Square			

***, **, * represents Significance at 1%, 5%, 10% level.

The model has a McFadden's Rho-square value of 0.2879 which indicates that the estimated model is well able to predict the observed choices Hensher et al. (2005). In addition, it appears that the assumption of heterogeneity is supported by a significant standard deviation for a number of attribute levels. It can be noticed that the means and standard deviations of attributes such as 'off-street parking tariff', 'on-street parking cost', 'level of parking convenience', 'surrounding activities', 'speed limit', 'number of streets already visited', 'average space available', 'payment options' and 'expected parking duration' are significant. According to the parameter estimates, if speed limit is 40km/h, the expected parking duration is more than 120 minutes, and the off-street parking tariff is low (0.50 euro/hour) then the probability that a car driver parks the car in an off-street parking increases. Moreover, free parking, providing parking closer to destination and roads with reduced speed limits (preferable residential areas) are the major conditions that induce parking search. Similarly, conditions that induce search traffic can be identified using the model results.

6. Conclusions

Nowadays, roads are crowded with search traffic, car drivers' parking choice decisions need to be reduced. For this a thorough investigation related to car drivers' parking choice decisions is required. In the current study, researchers try to inquire respondents regarding their on-street parking preferences using a stated preference approach including the integrated hierarchical information integration technique. In the current research, it is assumed that car drivers make parking choices based on the prevailing road conditions in the street such as speed limit, surrounding activities and parking space availability. The data collected has been investigated using Mixed Multinomial Logit Model. The results of the model estimation show that besides parking costs, expected parking duration, speed limit, space availability, number of streets already visited and surrounding activities play a considerable role when determining car drivers' parking preferences. The model also shows that car drivers' prefer to park off-street if surrounding activities in the street include shops. One of the goals of the adopted approach is to look first if street conditions have influence (limited investigated in the past). If the estimates of MNL-model are observed surrounding activities is significant which indicates that the road conditions do have an influence of car drivers' parking choice decisions. This research can further be used as a part of multi-agent simulation systems for predicting effect of change in parking policies on traffic situation of a city. Moreover, in future this research can be extended by the inclusion of socio-demographic factors in the current model. Also more advanced techniques such as driving simulator can be used for collecting car drivers' parking preferences.

References

Arnott, R., Rowse, J., 1999. Modeling parking. Journal of Urban Economics. 45, 97–124.

Arnott, R., 2006. Spatial competition between parking garages and downtown parking policy, Transport Policy, Elsevier, vol. 13(6), pages 458-469.

Axhausen, K. W., Polak, J. W., 1991. Choice of parking: Stated preference approach. Transportation, 18. 59-81.

Benenson, I., Martens, K., Birfir, S., 2008. PARKAGENT: An agent-based model of parking in the city. Computers, Environment and Urban Systems, 32(6).431–439.

Belloche, S., 2015. On-street Parking Search Time Modelling and Validation with Survey-based Data. Transportation Research Procedia, 6, 313–324. https://doi.org/10.1016/j.trpro.2015.03.024

Bifulco, G.N., 1993. A stochastic user equilibrium assignment model for the evaluation of parking policies. European Journal of Operational Research,Vol. 71. 269-287 .

Bonsall, P., Palmer, I., 2004. Modelling drivers' car parking behavior using data from a travel choice simulator. Transportation Research Part C: Emerging Technologies, 12(5). 321–347.

Brooke, S., Ison, S., Quddus, M., 2014. On-Street Parking Search: Review and Future Research Direction. Transportation Research Record: Journal of the Transportation Research Board, 2469, 65–75.

Chaniotakis, E., Pel, A. J., 2015. A. J. Drivers' parking location choice under uncertain parking availability and search times: A stated preference experiment. Transportation Research Part A: Policy and Practice, 82. 228–239.

Gallo, M., D'Acierno, L., Montella, B., 2011. A multilayer model to simulate cruising for parking in urban areas. Transport Policy,18(5).735–744.

Golias, J., Harvatis, M., Yannis, G., 2002. Off-Street Parking Choice Sensitivity. Transportation Planning and Technology. 25(4). 333–348.

Guo, L., Huang, S., Zhuang, J., 2013. Modeling Parking Behavior Under Uncertainty: A Static Game Theoretic versus a Sequential Neo-additive Capacity Modeling Approach. Networks and Spatial Economics, Volume 13, Issue 3. 327–350.

Hess, S., Polak, J. W., 2004. Mixed Logit estimation of parking type choice. In 83rd Annual Meeting of the Transportation Research Board, Washington, DC. 561–582.

Hess, S., Polak, J.W., 2009. Mixed Logit Estimation of Parking Type Choice. In: B.W. Sloboda (ed.) Transport Statistics, J. Ross Publishing Inc., Fort Lauderdale, USA, 77-102.

Hensher, D. A., King, J., 2001. Parking demand and responsiveness to supply, pricing and location in the Sydney central business district. Transportation Research Part A: Policy and Practice, 35(3), 177–196.

Hensher, D.A., Rose, J.M., Greene, W.H., 2005. Applied Choice Analysis: A Primer, Cambridge University Press, Cambridge, UK.

Ibeas, A., dell'Olio, L., Bordagaray, M., Ortúzar, J. de D., 2014. Modelling parking choices considering user heterogeneity, In Transportation Research Part A: Policy and Practice, Volume 70, 41-49.

Khaliq, A., van der Waerden, P., Janssens, D., 2018. Modelling Car Drivers' On-Street Parking Decisions using the Integrated Hierarchical Information Integration Approach. In 97th Annual Meeting of the Transportation Research Board, Washington, DC.

Litman, T., 2010. Transportation Cost and Benefit Analysis (II) Parking Costs. Victoria Transport Policy Institute, Victoria.

Litman, T., 2006. Parking management best practices: Victoria, BC: Planners Press.

Louviere, J. J.,1984. Hierarchical information integration: a new method for the design and analysis of complex multi-attribute judgement problems. Advances in Consumer Research, pp.148-155.

Louviere, J. J., Timmermans, H. J. P., 1990. Using hierarchical information integration to model consumer responses to possible planning actions: recreation destination choice illustration. Environment and Planning A, pp. 291-308.

Marsden, G., 2014. Parking Policy. In S. IsonZ C. Mulley (Eds.), Transport and Sustainability. Vol. 5, pp. 11–32. Emerald Group Publishing Limited.

Marshall, W. E., 2014. On-Street Parking. In S. Ison & C. Mulley (Eds.), Transport and Sustainability .Vol. 5. 361–380. Emerald Group Publishing Limited.

Miller, E. J., 1993. Central area mode choice and parking demand. Transportation Research Record, pp.14-13.

Ortuzar, J. D. D.,Willumsen, L. G., 2001. Modelling transport. Chichester, England: John Wiley & Sons.

Ottomanelli, M., Dell'orco, M., Sassanelli, D., 2011. Modelling parking choice behaviour using Possibility Theory. Transportation Planning And Technology, 34, 647-667.

Pel, A. J., Chaniotakis, E., 2017. Stochastic user equilibrium traffic assignment with equilibrated parking search routes. Transportation Research Part B: Methodological, 101, 123–139.

Shoup, D. C., 2006. Cruising for parking. Transport Policy, 13(6), 479–486.

Steenberghen, T., Dieussaert, K., Maerivoet, S., & Spitaels, K., 2012. SUSTAPARK: An Agent-based Model for Simulating Parking Search. Journal of the Urban & Regional Information Systems Association, 24(1). pp.63–76.

Thompson, R.G., Richardson, A.J., 1998. A parking search model. Transportation Research Part A 32, pp.159–170.

Train, K., 2003. Discrete Choice Methods with Simulation. Cambridge University Press.

van der Waerden, P., Oppewal, H., 1995. Modelling the combined choice of parking lot and shopping destination. Presented at 7th World Conference on Transport Research, pp. 16–21.

van Ommeren, J. N., Wentink, D., Rietveld, P., 2012. Empirical evidence on cruising for parking. Transportation Research Part A. 46, 123–130.

Vasconcelos, A. S., Farias, T. L., 2017. The effect of parking in local accessibility indicators: Application to two different neighborhoods in the city of Lisbon. International Journal of Sustainable Built Environment, 6(1), 133–142. https://doi.org/10.1016/j.ijsbe.2017.02.006

Waraich, R. A., Dobler, C., Axhausen, K. W., 2012. Modelling parking search behaviour with an agent-based approach. In 13th International conference on travel research behavior (IATBR), Toronto, Canada.

Young, W., Taylor, M., 1991. A parking model hierarchy. Transportation, 18(1):37–58.

Young, W., 2008 Modelling Parking. In: D. Hensher and K.J. Button (eds.) Handbook of Transport Modelling, Second Edition, Elsevier Ltd, Oxford, UK, 475-487.