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Parking at a distance: option for reducing traffic and parking pressure in urban areas?

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Abstract

Urban agglomerations face increasing problems in accommodating traffic and parking demand. An interesting option is to develop tailor-made shuttle services by bus from large, scarcely used, parking facilities at the edge of urban areas, towards specific spots within the urban area such as large companies, inner-city shopping areas or labour areas. This paper describes a study focused at exploring the viability of shuttle services. The study is based on modelling travel behaviour of employees of a large office located close to the inner city of a large urban agglomeration in the Netherlands. The study used conjoint choice measurement to explore the employees' attitude towards parking at a distance combined with company shuttle services. The paper describes the measurement approach and the main results. It was concluded that, under particular conditions, shuttle services might substantially reduce the parking problems at the office location.

1 Introduction

The growth of car traffic is an extremely difficult problem to tackle. Car property and car use is steadily growing, generating a growing demand for infrastructure capacity to enable car trips and to park cars. Increasingly, we face traffic situations where the costs are higher than the benefits: congestion, emissions and the use of scarce space, noise. In particular urban agglomerations suffer from these growing societal and environmental costs. There is distinct need to accommodate mobility needs for economic and social reasons and at the same time reduce the use of private cars because of environmental considerations.

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Reaching these aims requires an active role of public authorities and other key players who affect the modal choice of travellers.

Basically, policy instruments can be classified into three strategies: (a) reducing the need for physical transport (substitution), (b) making car use less attractive and (c) improve the attractiveness of alternative ways of transport. The first strategy implies re-arranging time-space patterns of households and individuals as well as encouraging tele-activities. Instruments of the second strategy are various price measures (such as road pricing, payment for parking, fuel prices) and access and routing limitations in urban areas. As to the context of the third strategy, one might think of location decisions (planning e.g. destinations closer to public transport facilities) and of providing more and better alternatives (such as rent of bicycles, public transport, shared car use). All three strategies have to be applied in co-ordination to reach a significant effect.

Due to various reasons, such co-ordinated policies appear to be very difficult to implement. One reason is that the key players involved often have different interests: for example the city authority aiming at high parking prices versus the shopkeepers in the central city district. Another reason is that traffic policy development, spatial policy development and urban economics development is in different hands and insufficiently integrated. A third reason is that we do not know enough about the possible impacts of various measures or the conditions for reaching maximum desired impacts. We should significantly improve our knowledge about travel behaviour.

Improving the knowledge and models of travel behaviour is one of the major goals of a research programme the authors are involved in, called Seamless Multi-modal Mobility (SMM). The programme encompasses various research projects considered important for improving door-to-door transport chains based on combinations of the use of (rental) car, public transport (buses, trains), bicycles, taxis, and so on. One of the aspects to be studied is travel behaviour.

Within this research context the authors were involved in a study, in co-operation with a large office located in a large agglomeration in the Netherlands, to investigate the preferences of office employees with respect to the concept of parking at a distance linked with shuttle services. The aim of the office management was to replace a substantial part of car-based door-to-door trips by multi-modal trip chains. One of the ideas was to concentrate parking at the edge of the congested urban area. Among others, a model for analysing potential 'market shares' of different service concepts had to be constructed.

This paper describes the study approach and the main findings. First, in section 2, some characteristics of the travel behaviour of the company employees are described. In section 3 data collection regarding the evaluation of the proposed alternative is discussed. Section 4 presents the results of the analysis in terms of the choice model, while in section 5 the model is used to evaluate some different strategies. Finally, in section 6 some conclusions are drawn.

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2 The empirical setting

As mentioned, the research focused on a large office at a location within an increasingly congested urban agglomeration. Work within the office concentrates on administrative activities, provision of training services and some selling services. About 1700 persons have their job in the building. An average presence of about 1200 employees per day was measured. For these employees, about 400 parking lots are available, including dedicated lots for top management (16), car-poolers (32) and motor cyclists (15). Extension of the number of parking lots is not permitted. The location is relatively well accessible from the higher road network. Moreover, several bus services from different directions are provided at a distance of a few hundred metres from the front door of the building.

To gather data on modal split, different sources of information were used, including a measurement by the office facility manager in 1996 and a questionnaire in the context of our research in 1999. Although these two measurements used different measurement methods, they allowed for the conclusion that dominant car use had intensified in the past few years up to a level of 55% of the employees. The share for car-pooling in the modal split reduced to about 5%, whereas the share for both public transport and bicycling reduced to a level of about 20% (all percentages based on our study).

The increased car use was expressed in terms of a high degree of occupation of the parking lots at the office location and increased car parking in the adjacent living area during office hours (7.00-19.00). The study revealed that about 25% of the employees parked regularly in the neighbourhood. People living here increasingly protested against this situation in the past few years. Increasingly, they had problems with less local traffic safety, visual disturbance and parking their own car close to their homes. Their induced the municipal authorities to introduce a policy of selective, authorised, parking in the area in 1999. This triggered the office management to explore different options for influencing car use by employees . One of the ideas was 'parking at a distance'.

3 Research approach

Before introducing a service for employees such as parking at a distance in combination with the provision of company bus shuttles, the provider of such a service is interested in a rich picture of the potential use. Such an exploration cannot simply be based on directly asking the employees whether they would use such a service. The context for deciding pro or contra use of the alternative largely depends upon the nature of the service quality and the parking context at the location of the office. Employees make trade-offs between questions like:

- how certain is the parking lot at the location at distance versus the location of the office?
- what do I have to pay for parking at or in the vicinity of the office versus using the bus shuttle?
- what can be said about the loss of time when using the shuttle? A high frequency of shuttling will reduce waiting time.

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- what will the level of comfort be when using the bus shuttle: can I get a cup of coffee in case I have to wait, or a free newspaper? Will a normal car be used or 8-persons vans?

In short: employees make trade-offs with respect to different service concepts. Choices pro or contra are ultimately based on trade-off based preferences.

Since in the specific situation no real-world data can be gathered (these services hardly exist), one has to focus on measuring preferences and basic trade-offs which employees make with respect to key attributes of travelling. The methodology of conjoint measurement, in particular stated preference and stated choice models, has proved to give a better explanation of choice behaviour with respect to this type of measurement problems than classical revealed preference models (e.g. Timmermans, 1984; Van der Heijden and Timmermans, 1988; Molin, 1999). Therefore, this methodology was adopted in the present study. The basic idea is to model the relationship between the preference for a specific service profile and the underlying factors, taken into consideration by the employees in the context of decision making about their travel behaviour.

The methodology consists of several steps that will only briefly be memorised. In the *first* step, the most important factors (called attributes) of decision making on home-to-work travelling have to be identified (for instance time and costs). In the *second* step, the basic variety in attribute levels is specified (for instance for time: 15 minutes, 30 minutes and 45 minutes). In the *third* step, these values are combined into so-called service profiles. The more attributes and attribute levels have been identified, the more combinations (profiles) are possible. A so-called full factorial design provides all possible combinations, whereas fractional designs are based on smart selective combinations of attributes enabling sufficient statistical analyses of the main effects of the attributes on the ultimate preferences. In that case the number of profiles can be reduced significantly. This is important, because in step *four* these profiles have to be evaluated by respondents in terms of their preferences. In this step the measurement task has to be specified. Different tasks are possible. The respondents can be asked to rate a profile in terms of some rating scale. Another option is to rank all the profiles from 'least preferred' to 'most preferred'. The third option is to have respondents choose one profile when systematically comparing profiles. These tasks have different advantages and disadvantages. In the *fifth* step of the methodology, the preference data is linked to the attributes. In case metric preference data has been gathered, regression analyses can be applied. Non-metric data requires the use of a different model, such as the multi-nominal logit model.

The following operational choices have been made with respect to the measurement task. Seven attributes were specified based on literature study, including other travel behaviour studies. They are a mix of push factors and pull factors. The levels of the attributes were based on literature as well as discussions with the office manager about the empirical setting in order to find a plausible variety of levels. Table 1 presents the results of these two steps.

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Table 1: Selected attributes and attribute values

Selected attributes	*Selected attribute values*
1. Change to find parking lot at office location	A: moderate chance B: small chance C: zero
2. Costs of parking in case no parking lots available at office location	A: no costs B: Dfl. 1.50 per hour C: Dfl. 3.00 per hour
3. Type of transport from parking facility to office location	A: 4-persons taxi B: 8-persons van C: large bus
4. Change in travel time excluding waiting and transfer time	A: increase of 10 min. B: no change C: decrease of 10 min.
5. Frequency of shuttle service from parking to office location	A: every 5 minutes B: every 10 minutes C: every 15 minutes
6. Additional services at parking place	A: not available B: coffee machine C: kiosk
7. Financial incentives by rewarding	A: no reward B: Dfl. 2.50/day of use C: Dfl. 5.00/day of use

The attributes and attribute levels can be combined in a full factorial design with 2187 unique profiles. Evidently, for measuring preferences, reduction is essential. Therefore, a choice has been made for a fractional design that enables parameter assessments for a main-effect-only-model, based on the basic design suggested by Addelman (1962). It is assumed that all interactions equal zero. The result is a limited set of 18 different service concepts for transfer between a parking lot at a distance and the office location.

Next, a questionnaire was made. For each profile employees were asked how many days per week they would choose the suggested service. Also, the respondents indicated how many days they choose the car to go to the office. Combining these data enabled us to determine how many days per week each employee choose not to use the shuttle service and drive straight to the parking lots at the office. This information is essential for the construction of the choice model. Apart from this choice data, other data, related to travel behaviour, parking behaviour and personal characteristics, were collected as well. These data include an indication by the respondents of the attractiveness of each of the profiles on a 10-point scale ranging from not attractive to extremely attractive. The additional data were used to make a more in-depth analysis of the parking problem at the location and its direct neighbourhood.

The (rather lengthy) questionnaire was given to all the 1700 employees in the building mid July 1999. In total 593 useful responses were returned to the

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researchers, a response rate of almost 35%, which is satisfying, considering the fact that the data collection was located in the summer holiday period. From the respondents 323 appeared to dominantly use the car for home-to-work travelling. Their responses could be used for the construction of the choice model. In the next section, some results of the analyses will be presented.

4 Construction of the choice model

The specification of a choice model focuses on the choice between the use of the car and the use of transfer services. For constructing this model, we used data on the frequency (per week) of use of the hypothetical transfer services. 104 of the 323 respondents stated not to have the intention to ever use the transfer service (frequency=0). Hence, in this analysis we used binary choice data for either the car or one of the 18 different service profiles. We applied the logit model to calculate the percentage of the trips that will be made using the transfer service, given different attribute levels. The model is characterised as follows:

$P(i) = \exp [V(i)] / [V(i) + 1]$, where

$V(i) = C(i) + V(i,1) + V(i, 2) + V(i, 3) + \ldots\ldots + V(i, n)$

$P(i)$ = probability of choosing service concept i
$V(i)$ = structural utility of service concept i
$C(i)$ = the general transfer utility value
$V(i,j)$ = the part-worth utility for i of attribute j (j= 1, …, n)

To calibrate the model, logistic regression analysis was used. To use this calibration procedure, the attribute levels were coded, such that the regression intercept represents the average appreciation for the 18 profiles and the other parameters the deviation from the average.

The results of the logistic regression analysis are presented in Table 2 in terms of the part-worth utilities and relative importance of the attributes. The value of the intercept gives the average utility as compared to merely using the car and thus not choosing for a kind of transfer service. In Table 2, the negative value indicates that on average there exists a slight aversion to the idea of using the concept of parking at a distance added with transfer services.

Table 2 further provides us the following information. For choosing between either using the car for door-to-door travelling or using the car for parking at a distance and additionally the shuttle service, the pre-specified attributes appear not to be equally important. Table 2 gives an indication for the relative importance of the attribute parameters. This has been calculated as follows. First, take the difference between the maximum en minimum utility that can be calculated, using respectively the maximum and minimum attribute value per attribute. Then add all these differences up to the total maximum difference in utility. And finally, calculate the share of the difference of each attribute in the total difference.

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Table 2: part-worth utilities in the choice model (n=323)

Attribute/attribute levels	Impor-tance	Part-worth utility
Regression intercept		- 0.75
1. Chance parking lot	16.5	
- moderate		- 0.31
- small		0.08
- zero		0.23
2. Parking coststst	3.5	
- zero		- 0.06
- Dfl 1.50 per hour		0.05
- Dfl. 3.00 per hour		0.01
3. Kind of transport	6.0	
- 4-persons taxi		- 0.02
- 8-persons van		0.10
- bus		- 0.09
4. change travel time	35.2	
- increase 10 minutes		- 0.68
- no change		0.23
- decrease 10 minutes		0.45
5. frequency shuttle	17.1	
- every 5 minutes		0.25
- every 10 minutes		0.06
- every 15 minutes		- 0.31
6. additional services	6.9	
- none		- 0.12
- coffee machine		0.02
- kiosk		0.10
7. reward	14.8	
- none		- 0.30
- Dfl. 2.50/day use		0.18
- Dfl. 5.00/day use		0.12

The result is a percentage indicating the degree to which differences in value add to increases or decreases of total utility for the transfer services. Four attributes appear to play an important role in explaining choice behaviour with respect to parking at a distance. They are respectively: change in travel time, frequency of shuttle service from parking place to office location, reward for using the service (all three pull factors) and the perceived change for finding a parking lot (push factor). The first two attributes are well known influences on decision making of non-captive travellers with respect to the use of public transport versus the car. The third attribute indicates that employees might be sensible to active stimulating policies. The fourth attribute is evidently important for assessing the relative attractiveness of parking at a distance.

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Table 2 also indicates that the parking costs are no weighty reason for changing travel behaviour. Moreover, in terms of the services offered (pull), neither the additional services offered nor the kind of vehicle used for shuttling heavily influence the decision making of travellers.

The part-worth utilities indicate that in case of an increase of travel time (as compared to the car) a substantial decrease of utility for the shuttle concept is generated. Further, the table shows that a frequency of 5 minutes is appreciated as opposed to a frequency of every 15 minutes. With respect to the attribute 'reward', the table indicates that some reward is appreciated. However, a higher reward receives a lower appreciation than a lower reward, which is theoretically not to be expected. Perhaps respondents considered a reward of Dfl 5,- per day of use not realistic. Finally, only in case employees expect to have hardly any chance to find a parking lot close to the office location, the attractiveness of the shuttle service increases. Even when one has the idea that parking problems are moderate, the appreciation for the shuttle service decreases.

In additional analyses we looked at differences between some personal characteristics. Firstly the gender (60% male and 40% female). Significant differences appeared with respect to travel time: the female respondents appreciate a decrease in travel time higher than male (and reverse: an increase of travel time generates a lower appreciation for women). Next, it was found that women have a much lower appreciation of a 4-persons taxi than men. Finally, a higher frequency is evaluated more positive by women than by men.

Secondly, we explored the possible influence of the age of the respondents. It was found that rewards are especially important for the younger. Also, possible changes in travel time generate more extreme reactions for the younger employees than for the older ones.

Thirdly, the distance from home to work is theoretically important for the evaluation of transfers in the multi-modal travel chain. It was found that almost half of the respondents travelled less than 18 kilometres to the office. Therefore, the response was split into long-distance travellers (> 18 km, n=108) and small-distance travellers (<18 km, n=111). The long-distance travellers have a higher appreciation for additional service at the parking place and a higher level of acceptance for a lower frequency of shuttle services, than the second group.

5 Evaluation of different strategies

As stated earlier, the main interest of the location manager was to assess the viability of different shuttle service concepts, based on parking at a distance. The primary target of the management set in this context was to arrive at a reduction of 25% of employees with a car at the office location, based on the size of the parking problems for the direct neighbourhood caused by the employees (section 2). Given the imbalance between parking lots available and the present demand for parking lots, this would relax the problem significantly. In that case the question is which shuttle service concept might induce such a reduction?

Evidently, the costs of the strategy to be implemented are also of great importance. A high frequency of shuttle buses combined with high rewards,

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might be an attractive and effective strategy, but is rather expensive. So, there was also much interest in calculating the effects of the cheapest shuttle service.

Finally, a third strategy is not to start the shuttle service solely, in co-operation with other, adjacent, offices. Co-operation could cause a better use of shuttle bus facilities and therefore a lower average cost level. Moreover, working together could lead to more pressure on municipal authorities to enable a free use of dedicated bus lanes and organise priority at traffic road crossings.

These three strategies have been translated into unique combinations of attribute levels, as presented in Table 3, Table 4 and Table 5 respectively. In all three strategies severe push factors are presented: hardly any chance to find a parking lot at the office (90% occupation around 9.00 o'clock in the morning) and payment for parking in the neighbourhood. Payment in the neighbourhood (excluded special permits for inhabitants of the neighbourhood) has been introduced second half 1999.

Table 3: Specifying characteristics of a '25% car reduction strategy'

Attribute	Level of attribute	Part-worth utility
Change parking lot	hardly	0.08
Parking costs	Dfl 2/h.	0.04
Kind of transport	8 p. bus	0.10
Frequency	10 min	0.06
Additional services	none	- 0.12
Travel time	+ 10 m.	- 0.68
Reward	Dfl 2.5	0.18
Intercept: - 0.75		
Total utility: - 1.09		
Reduction %: 25.2		

Also equal in the three strategies is the kind of transport: the use of the 8-persons van. Respondents had indicated their strong preference for this means of transport. In none of the three strategies a reduction of travel time was assumed to be likely in the short run. Therefore assumed increases in travel time vary from 5 to 10 minutes.

From Table 3 it follows that a shuttle service that causes a situation of 25% less times use of the car to reach the office location, is in particularly characterised by rewards for using the shuttle service. The frequency of the shuttle service is not higher than every 10 minutes. For the office manager, this strategy induces the question of introducing a reward system, which could make the strategy rather expensive. These costs should however be compared with costs of a strategy aimed at accommodating all employees with cars (e.g. buying parking permits in the neighbourhood).

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Table 4: Assessing impacts of car reduction strategy 'low costs'

Attribute	Level of attribute	Part-worth utility
Change parking lot	hardly	0.08
Parking costs	Dfl 2/ h.	0.04
Kind of transport	8 p. bus	0.10
Frequency	15 min	- 0.31
Additional services	none	- 0.12
Travel time	+ 10 m.	- 0.68
Reward	Dfl 0	- 0.30
Intercept: - 0.75		
Total utility: - 1.94		
Reduction %: 12.6		

Table 4 provides information with respect to a strategy with low costs for the office manager, apart from what has already been noted about the severe push factors, characterised by no rewarding and a frequency of services of once per 15 minutes. In this strategy, a reduction in car use of 1/8 can be reached. This would not be a sufficient result as compared to the goal of ¼ reduction.

Table 5: Assessing impacts of 'co-operation' strategy

Attribute	Level of attribute	Part-worth utility
Change parking lot	hardly	0.08
Parking costs	Dfl 2/ h.	0.04
Kind of transport	8 p. bus	0.10
Frequency	5 min	0.25
Additional services	kiosk	0.10
Travel time	+ 5 min.	- 0.23
Reward	Dfl 0	- 0.30
Intercept: - 0.75		
Total utility: - 0.71		
Reduction %: 33.0		

In Table 5, the strategy of co-operation with other offices in providing shuttle services is translated into attribute levels. The most important difference with the two previous strategies is the smallest increase of travel time (5 minutes) and the highest frequency of shuttling (every 5 minutes). Moreover, additional services are provided in a kiosk. Evidently, providing such a service level does not allow for rewarding. The analysis showed that a reduction in car use with approximately 1/3 seems possible with this strategy.

The three tables emphasize the importance of the attributes 'frequency', 'lost of time' and 'reward'. We stress that the calibrated model can also be used for evaluating scenarios for shuttle services characterised by attribute levels

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anywhere in the range assumed in this study. For instance a reward of fl. 3.50 or a travel time increase of only 3 minutes. Even small extrapolations outside the range can be made, although one should be very careful.

6 Conclusions

This paper addressed a valuable strategy for reducing parking problems in inner cities. The strategy is characterised by parking at a distance (the edge of congested areas) linked with regular shuttle services. In co-operation with a large office, we explored the preferences of employees and constructed a model to assess the potential impacts of different shuttle service concepts. Evidenty, the total study was much richer than described in this paper.

The constructed choice model appeared to be supportive to the office manager in terms of indicating the impact size of different shuttle service concepts. It was found that, on average, employees do greatly support for the idea of parking at a distance linked with shuttling. The overall appreciation is less than the use of the car for reaching the destination. However, certain conditions seem to improve the degree of support. On the one hand strong push factors are important. They increase the tendency to consider alternatives. Moreover, pull factors are important. For instance the rewarding of 'good behaviour'. Also the quality of the shuttle service itself is important: high frequency, short waiting times, priority in urban traffic, additional catering services. Smart combinations of push and pull factors might generate sufficient results to reduce parking problems in certain areas significantly.

The study indicates that co-operation with other offices might be very fruitful. Moreover, co-operation with municipal authorities is also important for planning the parking areas and for profiting from the benefits of dedicated infrastructures and priority rules for public transport.

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