MAP-BASED STATED-PREFERENCE SURVEY APPROACH FOR PARKING LOCATION CHOICE

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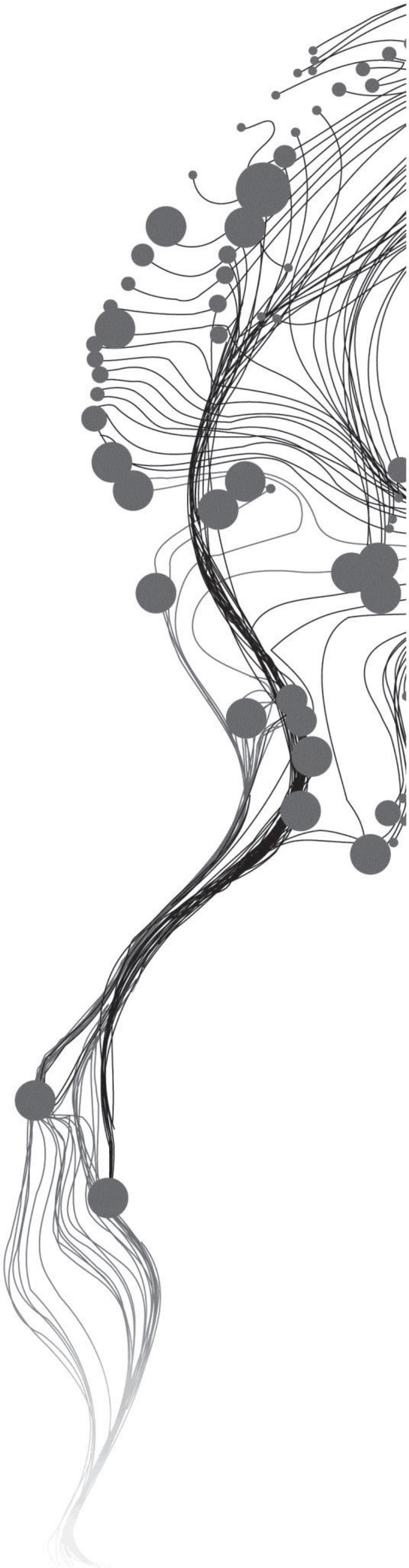

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YAN WANG

Enschede, The Netherlands, April, 2013

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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ABSTRACT

Parking is regarded as an important component in contemporary urban transport planning. Insufficient urban parking facilities and increasing parking demand have led to deconcentration, relocation of manufacturing and demands of resetting government policy. Therefore it has become imperative to think on how to arrange the superfluous parking demand in limited parking facilities. To solve this parking imbalance problem, there are several alternative solutions. For developing effective solutions it is necessary to study the parking behaviour and parking choice.

Stated preference (SP) experiments are becoming increasingly popular for investigating travel behaviour in general and parking location choice in particular. Two known SP methods are Contingent valuation and Stated choice modelling. Interviewees are presented with options varying in attribute values. These are usually presented numerically or textually or using pictograms (or combinations thereof). SP experiments based on maps have not been tried yet for location-based SP problems, which possibly reduce external validity problems. At the same time, it might pose other challenges like how to depict information accurately on the maps.

In this research, two map-based Stated Preference approaches have been developed, and compared. Instead of showing the alternatives in textual form, the scenarios, alternatives, attributes of the SP approach are all shown using maps. This makes that the alternatives have an explicit spatial connotation, making the distance to CBD attribute more real. At the same time it is also introducing possible 'other' locational preference information not attributed for the study. This more visual SP form reduces the risk of loss significant information or mischaracterization. Two websites were set up for the two kinds of map-based Stated Preference approaches in this research. The user interfaces consist of maps and questions. The participants make their choices and fill in the questionnaires, after which the results are directly collected and integrated by the background process.

A small-scale survey investigating the parking lot choice of Enschede was conducted. With the implementation of the new developed instruments and the analysis of the data collected by the instruments, the feasibility of the map-based approaches has been checked. In addition, alternative utility maps of parking lots in Enschede were been made as an illustration of possible further application of the survey results. Finally, based on the lessons learned during the implementation, suggestions for further uses of the map-based survey approaches are presented.

Keywords: parking location choice, Stated Preference approach, Map-based Contingent valuation method, Map-based Choice modelling method, parking policy

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Yan Wang
Enschede, February, 2013

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1. INTRODUCTION

1.1. Background

Parking is regarded as an important component in contemporary urban transport planning. It plays an enormous role in access and mobility, as well as contributes to economic development by supporting the overall transport system. However, since the early 20th century, the amount of urban population together with their ownership of vehicles around the world have increased so fast that this increased demand, amidst shortages in supply of infrastructure, including parking are creating a series of urban problems. Insufficient urban parking facilities and increasing parking demand have led to deconcentration, relocation of manufacturing, financial problems and demands of resetting government policy(Kornblum & Julian, 2010). Therefore it has become imperative to think on how to arrange the superfluous parking demand in limited parking facilities.

To solve this parking imbalance problem, there are several alternative solutions including creating more parking spaces, parking pricing, parking prohibition, restricted parking only for residents, Park &Ride facilities, stimulating the use of sustainable transport modes and land use planning Amongst the host of solutions, changing parking policy itself is one of the more effective ways. Parking policy intervention can change parking condition by the strong arm directly or change the long term parking condition by influencing parking drivers' behaviours. Parking behaviour may affect parking demand at two different levels;

- The first level (macro level) concerns the effects related to trip destinations and travel mode.
- The second level (micro level) which concerns the effects on the individual destination, parking lot choice and the choice of routes through the study area.

It is therefore necessary to build a method to test the efficiency of drivers' parking behaviours, which belongs to the micro level impact of the parking behaviour, in order to give suggestions for formulating parking policies. Previous research about parking behaviour found that parking costs play a significant role in the choice of parking lots (van der Waerden, 1998). A large number of theories recommend that local governments use parking prices in order to allocate excessively demanded parking spaces for users (van Ommeren, Wentink, & Dekkers, 2011). Policy makers are thus, interested to know how parking location choice is influenced by parking tariffs and also in relation to other factors influencing parking choice, both spatial factors and non-spatial factors. The spatial factors include the location of parking facilities, searching time for parking lots and distance from the parking lot to destination, whilst the non-spatial factors are comprised of amongst others the parking fee, hours of operation, function of the parking lot, duration of stay, parking lot's type, number of previous rejections from each facility, condition of parking surface and safety of the driver and driver's vehicle-assumed to concern vandalism.

Multiple approaches exist to study travel behaviour in general and parking location choice in particular. The most widely used approaches for studying location choice are Revealed Preference and Stated Preference (SP). The Revealed Preference approach is mainly concerned with people's real choices, whilst the Stated Preference approach discusses the behaviours under hypothetical situation and based on assumed alternatives.

Stated preference (SP) experiments are becoming an increasingly popular survey methodology for investigating travel behaviour (A. Collins, J. Rose, & S. Hess, 2012). Using a stated preference choice model, hypothetical scenarios simulate choices and understand preferences (Oh, Ditton, & Riechers, 2007). Although the stated preference model is being used in many areas and has been implemented in a number of cases, the model still has some shortcomings. These shortcomings may have arisen from the internal/construct validity problems and external problems. The external validity problem is the bias that arises from the hypothetical nature of the SP method. Due to its difficulty to set the alternative scenarios similar to a reality scenario or to explain the alternative scenarios clear, the Stated Preference survey approach results may suffer from the external validity problem. The internal validity problem is the bias that arises from the respondents themselves. Respondents have no incentive to make a choice in an SP experiment in the same way as they would do with the real situation. For example, we can obtain several answers from one participant, but sometimes the answers are not the same with revealed practical action. The internal validity problem, which is also called construct validity problem, is the bias that arises from the construct of SP method. For instance, aspects of market choice context, such as search costs, do not exist or are not part of SP experiments. Moreover, a number of modified SP survey approaches should be designed in order to minimize the impact of several experimental design issues.

During the collection of transportation related stated preference (SP) data, it is common practice to describe verbally the choice scenarios and options presented to survey participants. While a verbal representation may be an appropriate means to convey the true nature of some choice situations, one can argue that the contextual complexity of many transportation decision environments is such that it cannot be translated in textual form without taking the risk of loss of significant information or mischaracterization (Yamada & Thill, 2003). The unbiasedness of the SP data collection is strongly dependent on the ability of individual respondents to comprehend the hypothetical choice scenarios presented to them as intended. That is, since their responses are conditioned by how they perceive and how they process the information provided to them during the survey to describe the scenarios, there is no guarantee that they will behave in accordance with their stated preferences when they actually face the situations(Beaton, Chen, & Meghdir, 1998; Cantillo, Amaya, & Ortúzar, 2010; Wardman, Bonsall, & Shires, 1997). Therefore it is important to design SP survey instruments that are as realistic as possible to secure unbiased responses. Adding a map of the study area to the stated preference survey could be a good way to improve the visualization (thus interpretation, recognition) of the stated preference survey instruments. Most SP applications so far are either presented numerical/textual or using pictograms (or combinations thereof). Map-based SP experiments have not been tried yet for location based SP problems, which could possibly reduce external validity problems as well.

Enschede is a city and a municipality in Twente region, which is located in the province of Overijssel in the east of the Netherlands and parking is also an important issue in Enschede. In 2011, there were 66,091 passenger cars in Enschede, which needed a parking area measuring approximately 90 ha assuming the size of a standard parking bay is 7.5 m^2(Chaturvedi, 2012). According to Gemeente Enschede (2011), the city is facing two problems in relation to the imbalance between supply and demand of parking facilities. One is the problems is the surplus parking at certain locations, especially in residential areas and the other is insufficient parking at certain locations especially during peak hours resulting in demand spilling on streets, adjacent properties or neighbourhoods especially in the city centre.

There have been several studies on parking policy in Enshede the most recent being the study undertaken by Chaturvedi (Chaturvedi, 2012). The first phase consisted of analysing parking supply, the second phase on analysing parking demand, the third phase on allocating parking demand to parking supply and the last phase encompassed the making of suggestions and recommendations for parking policy. This approach however had a shortcoming in representing the reality for the parking demand analysis. This model assumed all drivers as the same and gives them the same weight to factors which influence their parking choice. However in reality, drivers have different choices based on their individual parking behavioural habits. It is quite important for parking demand analysis to simulate people's parking choice behaviour and investigate the justifications of their behaviours. Therefore in this research discussions on how to simulate people's parking choice behaviours will be presented. The research will also develop two new Map-based Contigent valuation approach and Map-based Choice Modelling approach and test the feasibility of such map based survey instruments by analysing people's parking location choice in Enschede.

The main objective of this research therefore is to build up the new developed Map-based SP approach and test and compare the two approaches by implementing the approaches in the case of analysis people's parking location choice in Enschede.

1.2. Research problem

1.2.1 Problems related with the study of how to build up a map-based SP approach

With high risks of loss of significant information or mischaracterization associated with the traditional SP, which is mostly based on the textual description and graphics, there is a demand of designing a new SP with better visualisation expressions. To test the feasibility of the new developed SP, a test survey will be undertaken in Enschede.

First is determining attribute criteria, alternatives and scenarios of this particular SP survey. To design an SP survey, the attribute level is linked with the survey method and survey objectives. The number of attributes and alternatives are closely linked with the data analysis method. A proper number of attributes and alternatives and proper number of sample number greatly affect the validity of the final result.

Second, there is little reference of how to add map visualisations to the SP approach. The traditional Stated Preference Approach only gives respondents non-spatial choices and text alternatives, but the alternatives cannot be translated in textual form without taking the risk of loss of significant information or mischaracterization. However the map-based survey approach being designed in this research can make the alternatives of the SP approach visual. It is more obvious for people making their choice. Nevertheless, the experience of how to connect the maps and the SP alternatives is limited.

1.2.2 Parking status quo and parking policy of Enschede

Increased vehicle ownership and new developments in urban areas have led to an increase in parking demand. Assessing future parking demand and planning for an efficient distribution of parking over the city has become a problem that most local authorities face and central to this is the ability to efficiently determine users' parking behaviour. Parking behaviour is a decision or a choice which is determined by a human's subjective desire. Factors influencing parking choice are the components of the parking choice, thus it is essential that they are better understood..

In trying to understand parking choice behaviour in Enschede, a model has been developed to simulate the choice of parking lots (Chaturvedi, 2012). The model considers five different location factors, which include; i. parking charges ii. noticeability iii. ease of searching, iv. safety and winter provision and v. condition of parking surface. However, the previous research makes assumptions about the importance of the various spatial and non-spatial factors in parking lot choice, which are not further tested. In other words, the tradeoffs between the various factors by its users have not been considered yet. This research will consider this aspect in an attempt to better understand parking behaviour.

1.3. Research questions and Objectives

The main objective of this research therefore is to build up alternative map-based stated preference approaches and test and compare the approaches by implementing the approaches in the case of people's parking location choice in Enschede.

1.3.1 What are the factors of parking location choice?

- Review of literature to find out parking choice influencing factors.
- Relate literature and reality of Enschede to find out the most probable parking choice influencing factors.

1.3.2 What are the present parking policies and problems in the study area?

- Review the literature and parking policy to find out the existing parking circumstances of Enschede.
- To implement two map-based Stated Preference approaches in the case of shopping trips in downtown Enschede against the impact of parking tariffs on parking behaviours.

1.3.3 What is an appropriate map-based survey tool to understand parking location choice?

- Review the literature to find out the advantages and disadvantages of alternative parking choice survey tools and approaches.
- To make sure which survey tool is better and how to develop and improve it.
- How does an appropriate map-based parking location choice survey tool look like?
- How should a map-based parking location choice survey tool be applied (including sampling approach)

1.3.4 What information is generated through the implementation of alternative map-based survey tools to understand parking location choice?

- Determine the sample for the map-based surveys.
- Choose the suitable experimental group for the map-based surveys.
- Summarize how the map-based Stated Preference Approach was applied in the case of shopping trips in downtown Enschede
- Check and test which kind of analysis method is suitable for the map-based Stated Preference approach.
- Compare and relate the two map-based Stated Preference survey results.
- Discuss possible policy implications of the model results from the Stated Preference approaches.

1.3.5 What are the lessons learned in the implementation of the alternative map-based parking location choice survey tools?

- Summarize the advantages and disadvantages of using map-based parking location choice tools in the case of parking location choice of Enschede.
- To conclude on the feasibility of the approach based on the advantages and disadvantages occurred in the case.

1.4. Conceptual framework

By studying the traditional Stated Preference approaches, we find out the shortcomings of it, this research developed two Map-based SP approaches to improve it. To test the feasibility of the new developed Map-based SP approaches, we use the case of the parking location choice preference in Enschede to implement them. (Refer to figure 1).

The conceptual framework consists of 3 main tasks:
- Approach development studying traditional SP and a conceptual design of the Map-based SP.
- Practical problem need to be studied the importance of the parking preference analysis and the parking status quo of Enschede.
- Implementation of the Map-based survey tools for the case of parking preference in Enschede.

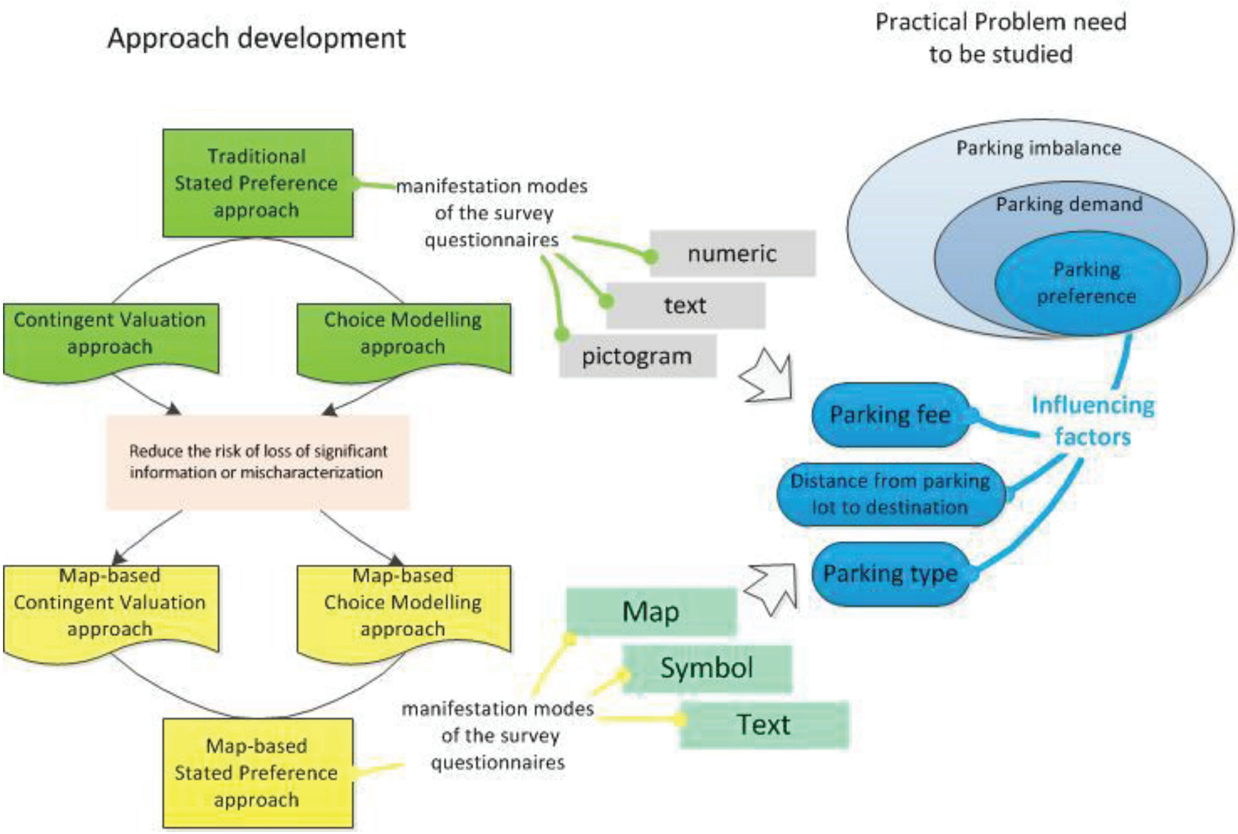


Figure 1 Conceptual Framework

1.5. Thesis structure

The thesis includes seven chapters. Below is a brief description of each chapter.

Chapter One: Introduction

This introductory chapter shows the background, research problems, objectives with the corresponding questions and research design.

Chapter Two: Literature review

First, factors that influence parking location choice will be discussed in this chapter. Further, methods to model and survey parking location choice will be discussed, including the parking location choice modelling approaches and parking location choice survey approaches.

Chapter Three: Setting up two map-based Stated Preference survey approaches

A full description of how to set up the map-based Contingent Valuation survey approach and map-based Choice Modelling survey approach are given in this chapter. It includes three parts: tool development, survey design and data modelling and analysis. It provides the insight into the whole research methodology.

Chapter Four: Model results of the two map-based Stated Preference survey approaches

This chapter discusses about the model results of the two map-based Stated Preference Approaches. The result of each approach is discussed separately at the very start. Then the CV result and CM result are compared. Finally, the Pro's and Con's of Map-based SP approaches are discussed.

Chapter Five: Lessons learned and policy implications for parking location choice in Enschede

This chapter discusses the advantages and disadvantages of the map-based Stated Preference Approaches from the point of view of the factors and methods; as well as some policy implications based on the test implementation surveys of Enschede.

Chapter Six: Conclusions and recommendations

This chapter concludes the advantages and disadvantages of the map-based Stated Preference Approach in actual implementation. And forecast the feasibility of the map-based Stated Preference Approach and give suppositions of the utilized fields.

2. SURVEY APPROACHES TO STUDY FACTORS AFFECTING PARKING CHOICE

Based on literature, this chapter first gives an overview of factors that influence parking location choice and secondly provides an overview of alternative approaches to survey and model parking location choice. The purpose of this chapter is to identify a theoretical framework for accomplishing the objectives defined in the research, based on previous works done on the subject.

2.1. Factors impacting parking location choice

To explore the tradeoffs in parking behaviour, firstly, we need to find out the parking choice influencing factors. The parking choice influencing factors, also the attributes of alternatives, consist of spatial factors and non-spatial factors (Dell'Orco & Teodorović, 2005).

The **spatial** factors include location of parking facilities, parking lots searching time and distance from parking lot to destination. The most important spatial factor is the distance from parking lot to destination, which is usually descripted by walking time from parking lot to destination. The value of the walking time has been derived, that of 5 €/h to 11.50 €/h for those parking on the first block and of 4.50€/h for those parking on the other blocks in the paper Development of a downtown parking model (Parunak, Ward, & Sauter, 1999). The parking allocation model of another model obtained values of walking time of 4.75 €/h for commuters and of 6.33€/h for all Central Business District (CBD)-bound travel. They all confirm that the walking time values for different area of city are different. The study by Austin (1973) developed a parking distribution model based on the trade-off between parking costs and walking distances. In this model, the calibration of the distribution for parking in the central business district of Los Angeles revealed mean values of walking time ranging from 10.80 to 15 for work commuters (Axhausen & Polak, 1991).

The **non-spatial** factors influencing parking choice are comprised of parking fee, hours of operation, function of parking lot, duration of stay, parking lot's type, number of previous rejection from each facility, condition of parking surface and safety of the driver and driver's vehicle-assumed to concern vandalism(Chaturvedi, 2012; A. T. Collins, J. M. Rose, & S. Hess, 2012; Dell'Orco & Teodorović, 2005).
A review of the published literature supports the important position of parking tariffs in parking choice (D. A. Hensher & J. King, 2001; Higgins, 1992; Peng, Dueker, Strathman, & Hopper, 1997; Young, Thompson, & Taylor, 1991). Without exception, all papers cite the absence of demand studies that can reveal the appropriate behavioural responsiveness to prices, location and supply restrictions(D. A. Hensher & J. King, 2001). But the most important and efficient factor of these is the cost of parking(Tsamboulas, 2001). Increases in tariffs of CBD will make it easier to find a space for those who are willing to pay the price. Decreases in tariffs outside the CBD will make a better utilization of existing space(Darst, 2011). The change of tariffs will lead to a noticeable relocation of parkers from close in to elsewhere in the CBD. Other, more price sensitive parkers have a greater tendency to park further out or shift to public transport use(Marsden, 2006).

Based on the study of D.A.Hensher(David A. Hensher & Jenny King, 2001), the hours of operation can be separated into three levels: i.e. open from 6.30 a.m., from 9.30 a.m. and 24hours. The operation hours of the

parking lots will become the determinant factor during some particular situation and hours in the parking location choice behaviour.
The function of parking lots separated into seven types by Ligocki (Ligocki & Zonn, 1984), which are general purpose; commercial; government; professional and medical; cultural and recreation; special use; and others. Different trip purposes influence both degree of parking emergency and willingness to pay for the parking.
According to the sample distance from the CBD(Goudie, 2002), the thresholds of the partition are: the inner or central of CBD is the district within 2.7 km far from CBD; the middle distance of CBD is from 2.7 km to 12 km far away from CBD; and the outer or the edge of CBD is from 12 km to 57 km far from CBD. So as discussed above, the threshold of the distance is based on the reality situation and context-specific research requirements.

Among the spatial factors and non-spatial factors discussed above, parking fee, distance from parking lot to destination, parking type and parking trip purposes are most important and general factors. Not the same as the factor of parking lot operation hour, which have determinant influence in some situations, these factors have general impact on most of the parking location choice behaviours.

In his analysis of parking demand in Enshede (Chaturvedi, 2012) discussed several parking location choice factors. These factors can be classified into two groups based on location factors of the parking lot and trip characteristics of the users as shown in Table 1 below .

Table 1 Factors used to calculate the suitability of parking lots (Source: (Chaturvedi, 2012))

Group	Factors
Trip Characteristics	• Walking time from parking place to destination (in minutes) • Trip purpose
Location characteristics	• Parking charges • "Noticeability" of the facility (assumed to be related to the size of the facility). • Condition of parking surface (whether smooth paved, rough paved with potholes or cracks, gravel or dirt) • Type of winter provision • The safety of the driver and driver's vehicle-assumed to concern vandalism • Ease of searching a parking lot (assuming that if it is on the street it is well visible)

Factor such as the condition of parking surface, type of winter provision and safety of the driver and driver's vehicle-assumed to concern vandalism can all be included into the parking lot quality.

2.2. Methods to model and survey parking location choice

2.2.1. Methods to model parking location choice

2.2.1.1. Agent-based simulation models

An agent-based approach simulates the behaviour of each driver in a spatially explicit environment and is able to capture the complex self-organizing dynamics of a large collection of parking agents within a non-homogeneous (road) space. The model distributes the key values like walking distance, search time, and parking costs over different driver groups. It is developed as an ArcGIS application, and can work with a practically unlimited number of drivers (Benenson, Martens, & Birfir, 2008).

Agent Technology (Gonzalez-Morcillo, Weiss, Jimenez, Vallejo, & Albusac, 2007) aims to provide new concepts and abstractions to facilitate the design and implementation of systems of this kind. The following are characteristics of an ideal agent technology application as listed (Parunak et al., 1999).

- Modular, in the sense that each entity has a well-defined set of state variables that can separate it from its environment and the interface of the entity to the environment can be clearly identified(Davidsson, Henesey, Ramstedt, Törnquist, & Wernstedt, 2005).
- Decentralized, in the sense that the application can be decomposed into stand-alone software processes capable of performing useful tasks without continuous direction from some other software process(Davidsson et al., 2005).
- Changeable, in the sense that the structure of the application may change quickly and frequently(Davidsson et al., 2005).
- Ill-structured, in the sense that all information about the application is not available when the system is being designed(Davidsson et al., 2005).
- Complex, in the sense that the system exhibits a large number of different behaviours which may interact in sophisticated ways(Davidsson et al., 2005).

Agent-based modelling can simulate the complex dynamics of the studio system in detail and generate data about the system performance for different groups of participants especially in saturated parking citations. The strength of this approach reflects especially in areas of air and road traffic management agent technology. It seems to have contributed significantly to the advancement of state-of-the-art (Davidsson et al., 2005).

But the agent-based modelling approach also has significant weakness. Although agent-based modelling is quite mature; few fielded experiments have been performed and very few deployed systems could be found. The suggested agent-based approaches are often not evaluated properly and comparisons with other existing techniques and systems are rare. The qualitative assessments explaining both the pros and cons of agent technology compared to the existing solutions, also the quantitative comparisons to these solutions, are desired(Davidsson et al., 2005).

2.2.1.2. Discrete Choice Models

Discrete Choice Modelling is also called Choice-Based Conjoint Analysis; it belongs to the Multivariate statistical analysis. It is a commonly used method in the research area of sociology, biostatistics, quantity, psychology, marketing and statistical empirical analysis(Takama, Tsephel, & Johnson, 2012). The objective of

Discrete Choice Modelling is using specific individual or specific categories of covariant to explain the observed selected result among the discrete objects. The model simulates the hypothetical situations based on the experimental design, tests the participants' behaviour, and gets the results of people's selections and preference under the assumed situation(Rust, 1988).

The Discrete Choice Model consists of four logit models, which are: 1. The Multinomial Logit Model, 2. The Nested Logit Model, 3. The Cross-Nested Logit model and 4. The Network GEV model(Bierlaire, Bolduc, & McFadden, 2008). For each model, the function is different. Different models are appropriate for different research situations and objectives.

2.2.2. Methods to survey parking location choice

The parking location choice survey is mainly to analyse people's preference. The survey methods are the same with the Willingness to pay survey method. In the figure below, literature classifies the different methods for estimating WTP into revealed and stated preference methods (see Figure 2). The two methods are designed and used depending on the type of goods or services in question (and the time and research resources available). Revealed preference methods (RP) refer to the observation of preferences revealed by actual market behaviour. Moreover, RP data provides valuable information for modelling choice behaviour as the choices reflect decisions that have actually been made. Stated preference methods (SP) refer to the observation of preferences revealed by behaviour based on the hypothesis scenarios.

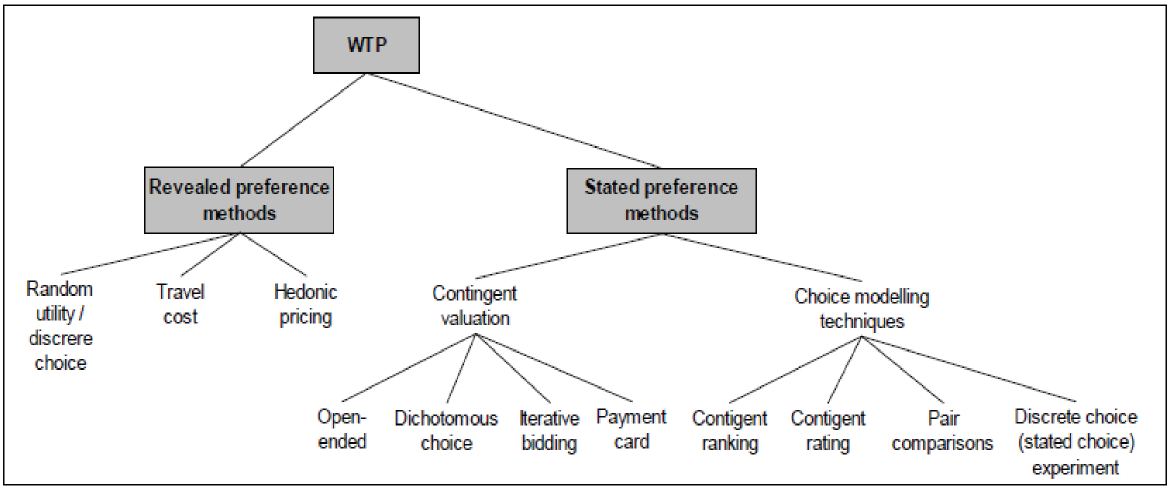


Figure 2 Willingness-to-pay methods (sources: Bateman et al. (2002), Kjaer (2005))

2.2.2.1. Revealed Preference approach

Revealed preferences are tested to rationalize an economic agent's observed action. It sometimes makes sense to assume that revealed preferences are identical to normative preferences. But the revealed preferences can rationalize the observed actions in many cases where this assumption is violated(Beshears, Choi, Laibson, & Madrian, 2008).

The revealed preference approach is frequently used to evaluate consumer demand and produce conditions, inequalities of supply and demand and the generalized axiom of revealed preferences (GARP), under which a well-behaved utility function rationalizes the data(Fleissig & Whitney, 2011).

A revealed preference theory is a method which can be used for comparing the influence of policies on consumer behaviour. The model assumes that the preferences of consumers can be revealed by their purchasing habits(Varian, 2012). The revealed preference method has generally been used to survey people's behaviours based on their purchasing habits(Vermeulen, 2012). The revealed preference method is mainly based on the data getting from the existing systems (Hu, Sivakumar, & Polak, 2012). So there is a shortcoming for forecasting future scenarios of the revealed preference survey.

Early applications of discrete choice analysis used revealed preference (RP) data (i.e., data describing actual behaviour) to predict aggregate market behaviour based on objectively measured variables.

"Revealed preference" is based on observations on past or present actual market choice behaviour - either monitored by the researcher or reported by individuals across one or more time periods(Ben-Akiva et al., 1994). So this approach can only analyse the problems or estimate the situation for the existing circumstances.

2.2.2.2. Stated Preference approach

Stated preference (SP) experiments are becoming an increasingly popular survey methodology for investigating travel behaviour(A. Collins et al., 2012). Using a stated preference choice model with hypothetical scenarios to simulate participation choices and understand preferences, study objectives were to identify participators" preferences for various types of choices(Oh et al., 2007).
Nevertheless, some evidence suggests that SP experiments do not mirror decisions in reality. With an increasing number of people making real world decisions by use of the internet, the idea of aligning the choice environment with such online portals could improve the realism of the SP counterparts of such choices (A. Collins et al., 2012).

2.2.2.3. Comparison between the RP method and SP method

There are two different perspectives to compare the two kinds of preference methods (revealed Preference, RP, and Stated Preference, SP). The first perspective is to subdivide the two methods into subsections and compare data of each subsection. The comparison is composed of both the import data being used in the two methods and the output data collected from the two different approaches.

Table 2 Comparison between RP and SP Data

	Revealed Preference data	Stated Preference data
Preference Information	• The result of the actual behaviour • Consistent with the behaviour in the real market • We can get "Choice" result	• Expression under the hypothetical situation • Possibility of inconsistency with behaviour in the real market • We can get "Ranking", "Rating", "Choice", etc.
Alternatives	• Only existing alternatives	• Existing and non-existing alternatives
Attributes	• Measurement error • Limited range of attributes' levels • Possibility of collinearity among attributes	• No measurement error • Extensibility of the range of attributes' levels • Controllability of the collinearity among attributes
Choice Set	• Non-clear	• Clear
Number of Response(s)	• One response per respondent	• One or more response(s) per respondent

The first perspective is mainly about the comparison of the data. The second perspective pays more attention to the differences of the methods. The table below concludes the difference between the revealed preference method and the stated preference method, also the advantage and disadvantage between them.

Table 3 Revealed and stated preference methods (Sources: adapted from Kjaer (2005))

	Revealed Preference method	Stated Preference method
Approach	Consumers' preferences are revealed through their actions in real markets	Consumers are asked to state their preferences for hypothetical scenarios/alternatives that comprise a set of attributes and different levels of these attributes
Direct methods	Competitive market price (Observation of market prices)	Contingent valuation (Directly asking individuals their WTP)
Indirect methods	• Travel cost method • Hedonic pricing method • Discrete choice	Discrete choice experiment (estimation of the WTP by use of price variable)
Applicable goods	Real Goods	Hypothetical and real goods

	Revealed Preference method	Stated Preference method
Disadvantages	• Limited to supply of information regarding values that have been experienced • Limited number of cases where non-market values/goods exhibit a quantifiable relationship with market goods • Choice sets, attributes of choice options and individual characteristics are not controlled and/designed a priori but rather occur/co-occur	• Observed preferences may not reflect actual behaviour • Absence of incentive for the respondent to provide accurate responses • Incentive for respondent to behave strategically • Overall costly evaluation (more complicated to design and analyse, and also more costly to undertake a survey as show material often required for more complex choice task) • Vulnerable to violation of economic decision-making
Advantages	• External validity is maximised because the choices observed are real market choices in which consumers have committed money, time and/or other resources • Low-cost evaluation	• Provides preferences and information that are otherwise impossible to reveal when actual choice behaviour is restricted in some way

As discussed and compared of the two methods to survey parking location choice, the Stated Preference approach is more appropriate than Revealed Preference approach for this research objective. The SP approach has more study situations: the SP approach can study both behaviour under hypothetical situation and actual behaviour, but the RP approach can study only actual behaviour. The SP approach has more study alternatives: the SP approach can study both existing alternatives and non-existing alternatives, but the RP approach can study only existing alternatives. The SP approach has more study alternatives: the SP approach can study both existing alternatives and non-existing alternatives, but the RP approach can study only existing alternatives. The attributes of RP approach may have measurement errors, but SP approach will not meet this problem. So related with the case of Enschede, the Stated Preference approach is a better choice to improve and develop.

2.2.3. Stated preference methods for parking location choice

The Stated preference approach consists of two approaches. One is the Contingent Valuation method, the other is the Choice modelling method. The Contingent Valuation method is mainly study the willingness to pay for the uneconomic factors. The Choice Modelling method is mainly about the impact of the influencing factors to the preference and the interaction of the factors.

2.2.3.1. Contingent Valuation Method

Contingent valuation method (CVM) is a survey method in which respondents are asked how much they are willing to pay for the use or protection of the natural environment created under hypothetical market. It is a nonmarket-valuation method that is used to value specific changes from the status quo. Contingent valuation

(CV) is a widely used, but controversial survey-based technique for estimating the nonmarket benefits of environmental goods and services (Vossler & Kerkvliet, 2003).

The CV survey approach consists of three basic parts. Firstly, there are some attitudinal and behavioural questions asked as a preparation for the valuation questions below. Second, some Contingent scenarios are given to respondents asking for their monetary evaluations. The scenarios are hypothetical ones. Finally, the socioeconomic and demographic characteristics of the respondent are asked (Organisation for Economic, Development, Pearce, Atkinson, & Mourato, 2006).

The Contingent valuation method studies participants' behaviour through the questionnaire based on the hypothetical market where the good in questions. Through their express or reveal behaviour, their maximum willingness to pay (or willingness to accept) for hypothetical change in the level of provision of the good is calculated(Organisation for Economic et al., 2006).

Although CV has been widely used, it is still controversial, because the Contingent valuation method does not take the interaction of factors into consideration and that may cause a bias or an undiscovered impact to the final results. CV surveys ask respondents what they are (hypothetically) willing to pay for a well-defined good or policy change. The CV method is applicable to almost all non-market goods, and it is one of the very few available methodologies which can capture all types of benefits from a non-market good even containing those unrelated to current or future use(Organisation for Economic, Development, Pearce, Atkinson, & Mourato, 2006).

CV welfare estimates of damage assessment cases in natural resource are legally admissible, and numerous related applications have informed policymakers. However, the validity of CV estimates is the subject of an ongoing, heated debate among government entities, economists, lawyers, businesses, and environmental groups (Portney, 1994).

Emerging literature investigates the validity of CV by comparing responses to hypothetical questions with actual behaviour (Vossler & Kerkvliet, 2003). This research can be grouped as: (1) comparisons of CV with indirect valuation methods based on observed behaviour(Carson, Flores, Martin, & Wright, 1996); (2) comparisons of CV responses with actual market transactions(List & Shogren, 1998); (3) simulated market studies that compare one group presented with a hypothetical decision to another group presented with an analogous decision where money is actually exchanged(Champ, Bishop, Brown, & McCollum, 1997); and (4) comparisons of hypothetical and actual voting behaviour.

2.2.3.2. Choice Modelling Method

There is general acceptance amongst both practitioners and policy makers that the contingent valuation method is the most versatile and powerful methodology for estimating the monetary value of changes in non-market goods(Organisation for Economic et al., 2006). However, this approach still has limitations an reflecting the interactions of factors. The Choice Modelling approach is a subsequent approach developed to solve this problem. As the Choice Modelling approach is able to reflect the interactions of the factors and attributes, an obvious strength of CM lies in its ability to value multidimensional changes.

Choice models are used to estimate trade-off ratios among attributes and predict future market demand, either for existing products or services in conjunction with changes in attributes or for an entirely new product or service. While one can set up choice experiments based on hypothetical scenarios and ask respondents for preference statements about them, the consistency of SP data with actual market behaviour is always questionable(Ben-Akiva et al., 1994). So how to set up the Choice models and the alternative scenarios is quite important.

In order to measure nonmarket values in CM studies, a series of questions called 'choice sets' are presented to survey respondents. For each question, respondents are asked to choose one preferred option from several alternatives. One of the choice options is usually given as a 'status quo' or 'no action' policy, whilst other 'change' options are designed using variations in the levels taken by constituent 'characteristics' or 'attributes'. One attribute typically represents a monetary variable (known as 'payment vehicle'), which enables the derivation of implicit prices(Choi, Ritchie, Papandrea, & Bennett, 2010).

Although the Choice modelling approach is developed to solve the problems of the Contingent Valuation Method, it still has its own limitations. The choice complexity or depth of a ranking task can lead to greater random errors or at least imprecision in responses. Handling repeated answers per respondent also poses statistical problems and the correlation between responses in such cases needs to be taken into account and properly modelled(Bhatta & Larsen, 2011).

2.2.4. Map-based and web-based SP survey methods

A research discussed the impact of traffic images on travel time valuation in stated-preference choice experiments has been finished in 2011(Rizzi, Limonado, & Steimetz, 2011). The research incorporates images into the SP experimental design, and uses the image-based SP to test the impact of these images on congested VTTS (value of travel time savings), free-flow VTTS, or the 'congestion premium' implied by their difference. The main innovation of this research is using images to alternative present choice scenarios to the respondent. The respondents face a computer-based survey instrument, they are asked to indicate their choices using the computer's keyboard. The images of the survey instrument are used to depict general differences between congested and free-flow traffic conditions. There will be some biases, if the SP survey instruments are unable to tie their hypothetical travel scenarios to real-world travel experiences. However, the descriptions of scenarios using traffic images in this research improve the correspondence between hypothetical and real-world travel conditions.

A complementary but less common approach is to supplement written descriptions of attributes with images that roughly depict the traffic conditions for each alternative (Rose, Bliemer, Hensher, & Collins, 2008). There is little research devoting to incorporate images into the SP experimental design, which may due to the time and expense of doing so within already-costly experiments(Rizzi et al., 2011).

In recent years, transport surveys through e-mails or web sites have been widely put into use (Iragüen & de Dios Ortúzar, 2004). These studies provide abundant references and practical experiences of web survey design and analysis. E.g. there is a Google-Map Integrated web-based Stated Preference Survey to study the behavioural understanding of traveller response to Low Speed Private Transportation Mode has been implemented in 2009 (Asakura & Liu). This survey talks about both the embedding of Google maps into the

SP survey and the implementation of this through internet. This research uses an intention survey of Low Speed Private Transportation Mode usage in Kobe Sannomiya area to test the feasibility of the design.

As discussed above, both the Contingent Valuation Method and Choice modelling method are fully developed and widespread used Stated Preference methods. The Choice modelling method is inclined to study the impact of the different influencing factors on the parking location choice also the interaction between factors. The Contingent Valuation Method tends to estimate the nonmarket benefits of environmental goods and services; it is to get the willingness to pay for environmental goods and services. But all in all, both the Contingent Valuation Method and Choice modelling method have the same shortcomings. That is the lack of visualizations in representing the situation and alternatives. There will be some biases, if the SP survey instruments are unable to tie their hypothetical travel scenarios to real-world travel experiences. As discussed above, using the images instead of text can improve the description. The same with the image description method, using maps to descript the scenarios is a good way to improve the visualization of the survey instruments. It also improves the correspondence between hypothetical and real-world parking situations in this case, which is better for respondents to make their choices. Map-based SP approaches and the web-based survey method is a good way to solve this problem in order to improve and perfect the two Stated Preference approaches.

3. DEVELOPMENT AND DESIGN OF MAP-BASED STATED PREFERENCE SURVEY APPROACHES FOR ENSCHEDE

3.1. Survey design

3.1.1. Status quo of parking in Enschede

Enschede is a city and a municipality in Twente, in the Southeast of the Dutch province of Overijssel. The parking problem is recognized as a very important issue in Enschede. There were 66,091 passenger cars in Enschede in 2011, hence a requirement of approximately 90 ha of parking area in the city at all times assuming a standard parking bay size of 2.5m*5m = 7.5 m²(Chaturvedi, 2012).

Current parking lots can be separated into three types: On-street parking, Off-street parking and Garage parking. There are 93 parking lots located inside the Centre Ring Road. These have been taken into consideration in this thesis. There are 5 garage parking lots, 12 off-street parking lots and 76 on-street parking lots. The parking fee of the parking lots is 1 euro per hour, except for 4 garages where parking fee are 1.9 euro per hour.

As mentioned in a presentation by Gemeente Enschede (2011) the city faces problems of imbalance of parking supply and demand, which manifests itself as excess parking at certain locations, especially in the residential areas. The other concerns insufficient parking supply at certain locations especially during the peak hours. This results in demand spilling on streets, neighbourhoods or adjacent properties especially in the city centre.

The case study area is only inside and around the ring area of Enschede because of people’s walking time after parking their cars from the parking lots to the destination. This study considers that this walking time should be less than 30 minutes to be realistic candidates, and due to data availability. According to Chaturvedi the ring area of Enschede has almost 22,210 parking spaces (Chaturvedi, 2012), which is depicted in figure 3.

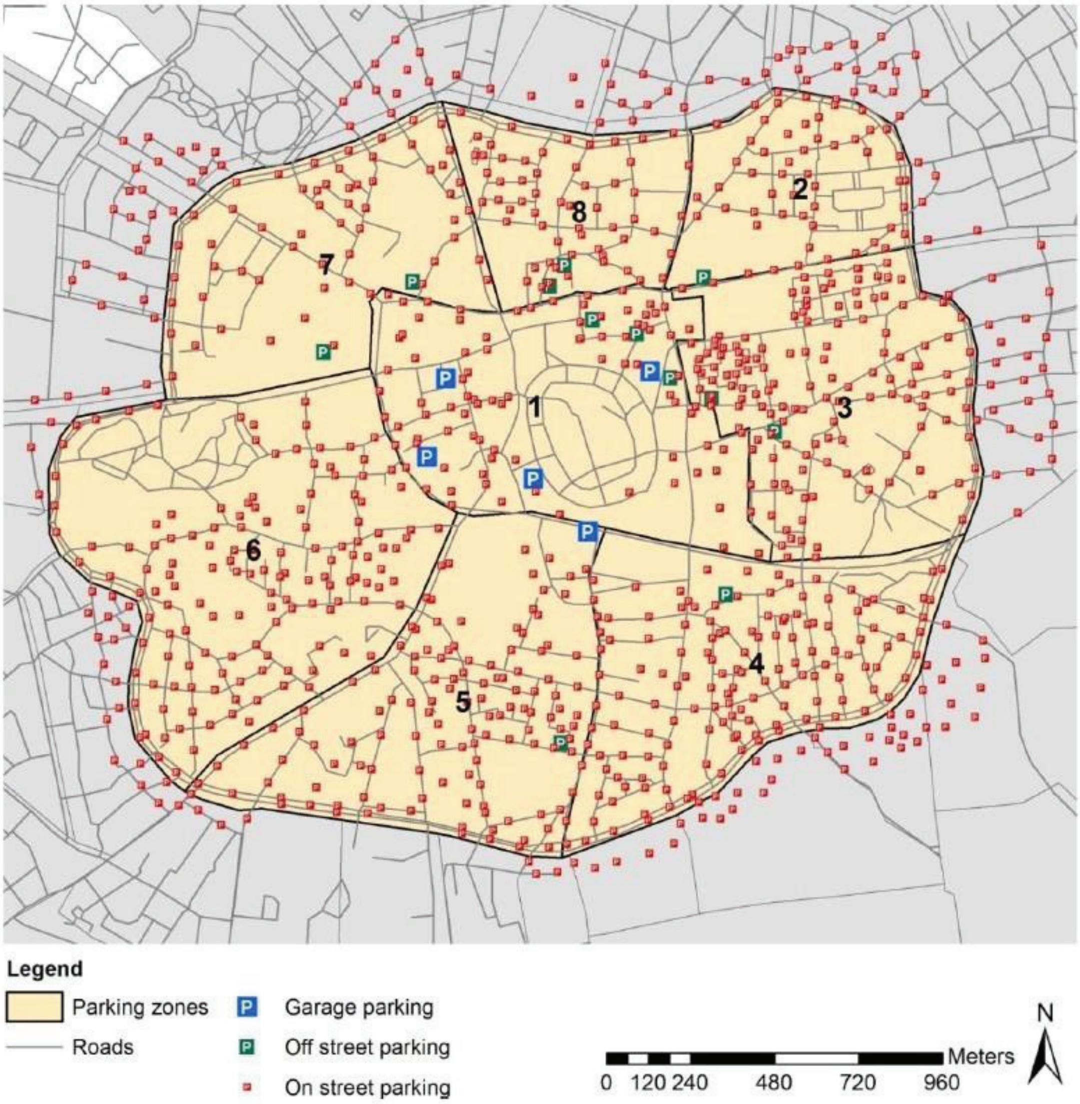


Figure 3 Enschede Parking lots and zoning (Source: (Chaturvedi, 2012))

Based on the location and the parking type, 42 parking lots have been selected considering both the parking type and the parking lot location. The number and parking tariffs of these parking lots are shown below (See Table 4).

Table 4 Number and parking tariffs of parking lots in Enschede

	Number of parking lots	Parking fee
Garage parking lots	5	4 for 1.9€ per hour 1 for 1€ per hour
Off street parking lots	10	1 € per hour
On street parking lots	27	1 € per hour
Total parking lots	42	

3.1.2. Selection of attributes & levels and the sample approach

To build the map-based CV survey questionnaire and map-based CM survey questionnaire, the first step is to make sure the attributes of survey and the attribute levels. To implement the survey, determination of the sampling data and respondent approach is a basic preparation step. These will be discussed in this part.

3.1.2.1. Attributes and levels of CV survey: banded attribute levels

In general, the more test variables, the more assumed scenarios one will need. So in order to balance the number of the test variables and the scenarios, the factor of distance from the parking lot to destination is classified and reduced. There is an O-D distance (or skim) matrix which shows the costs to traverse from origins to destination, which can be used for further classification analysis. For this case the parking lots are the origins and the centre of Enschede is treated as a destination. The costs are represented by the distance (meters) and walking time (minutes). For the analysis of walking time, a speed of 5 km/h is assumed as average walking speed. Based on the walking time from the parking lots to the centre of Enschede, three distance levels have been set. The short distance level consists of parking lots whose walking time from the parking lots to the centre of Enschede is below 6 minutes. The second level is moderate distance level whose walking time is from 6 minutes to 12 minutes. The last level is long distance level whose walking time is from 12 minutes to 18 minutes. The number of different types of parking lots is shown in Table 5. The distribution of the parking lots with distance levels is shown in Fig 4.

Table 5 Number of different types of parking lots

Distance from parking lots to destination / Type of Parking lots	Short distance	Moderate distance	Long distance
Garage parking lots	4	1	0
Off street parking lots	0	8	2
On street parking lots	4	2	21
Total parking lots	8	11	23

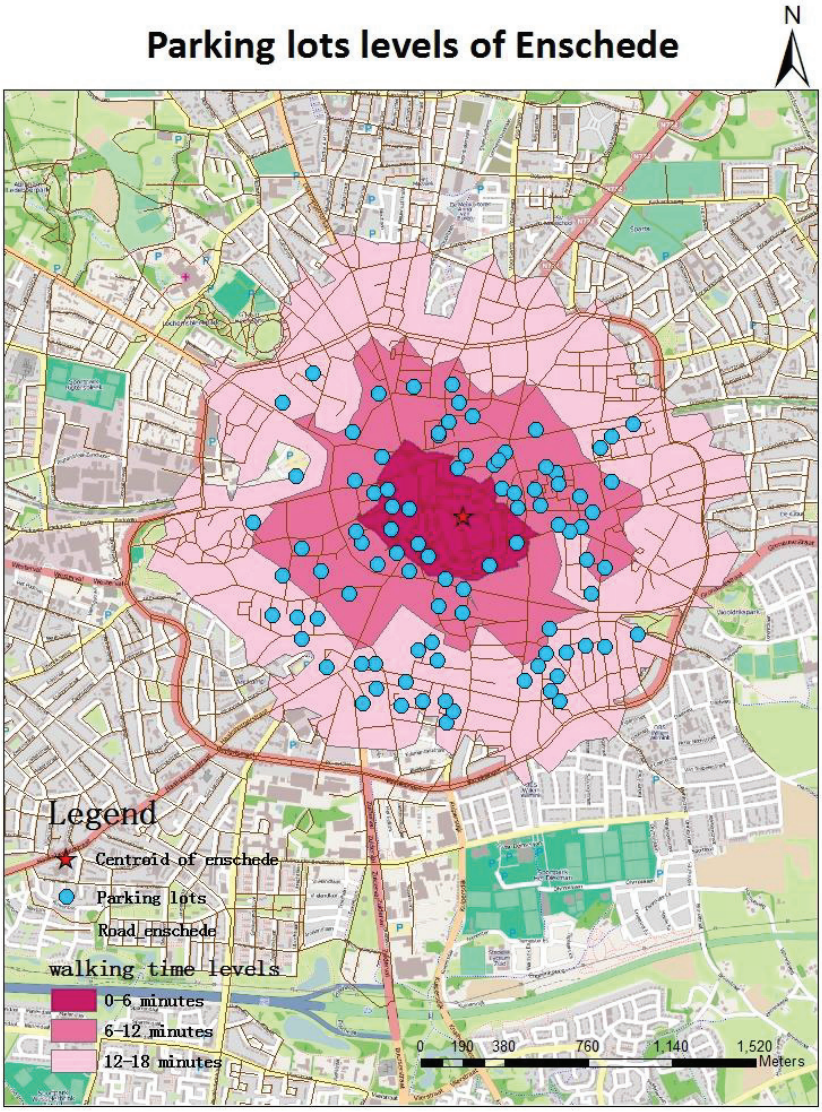


Figure 4 Parking lots with O-D walking time level

To discuss the impact of parking tariffs to the parking location choice, three different scenarios (A, B, C) with different parking tariffs have been defined. Scenario A changes parking tariffs by 20%, which implies an increase in parking fees of the short distance level parking lots by 20%, retain the parking fee of moderate distance level parking lots, and decrease the parking fee of long distance level parking lots by 20%. Scenario B changes the parking tariffs by 30% in the same way, while Scenario C changes the parking tariffs by 50%.

3.1.2.2. Attributes and levels of CM survey: continuous attribute levels

For the Choice modelling survey, attributes are the same with the Contingent valuation survey. They are distance from parking lot to destination, parking fee and type of parking lot. The value of the attribute distance from the parking lot to destination is also calculated with the O-D distance matrix, which shows the costs to traverse from origins to destination. In this case, and the same with the CV survey, parking lots are the origins and the centre of Enschede is treated as a destination. Costs are represented by distance in meters and walking time in minutes. For the analysis of walking time, a speed of 5 km/h is assumed as average walking speed. But, unlike the CV survey, the attribute distance from parking lot to destination are not classified into levels, the actual value is directly used. As the number for each pie of the survey are all six, one garage parking lot, one off-street parking lot and four on-street parking lots. There are 9 pies based on the entry points, so the total number of parking lots is 54 in the CM survey. The value of attribute type of parking lot is represented with 1, 2 and 3. The value of the garage parking lot is 3 as the quality of this type of parking lot is the highest. The value of off-street parking lot is 2, as the quality of this type of parking lot is moderate. The value of on-street parking lot is 1, as the quality of this type of parking lot is the worst of the three.

3.1.3. Sampling data and respondent approach

The experiments of the two map-based Stated Preference survey approaches within the scope of the study are designed to test whether the new developed map-based SP survey approaches are executable, and to give a glancing result of the impact of the parking influencing factors to the parking location choice, thus helping to see if further and more large-scale research on incorporating maps in the SP experimental design is warranted. So the two experiments are only small-scale ones, and the data analysis results are only glancing results.

Different data selections for the two map-based Stated Preference survey approaches were made. For the map-based Contingent Valuation survey only a group of international students, studying ITC in the MSc course Geo-information Science and Earth Observation for Urban Planning and Management (UPM) were selected to participate. The questionnaire survey was implemented by sending an Email request to the sample group. The Email consisted of an invitation letter explaining the research background, objective and a link to the website. The mail was sent to a group of UPM students in ITC is 50. In total 38 respondents completed the survey, which is a response rate of 76%, which is relatively high. Based on the experience of previous research, the group is naturally not very representative for the average parking place seeker as most of the students don't possess a car and never make use of parking places. However, the exercise should be seen as a simulation that when the people don't have a willingness to participate the survey based on the experience the response rate is still not very low.

The sample group selected for the map-based Choice Modelling survey is bigger than the CV survey. All the staff from academic departments of ITC were invited to this survey. The number of the target group is 123. The same with the CV survey, an Email including an invitation letter explaining the research background, objective and a link to the website was sent to all people of the sample group. 42 participants submitted a complete survey. Because each participant finished four choice sets, a total of 168 results were available in the end. The same with the CV survey, the nature target group is the shoppers coming to Enschede city centre by cars, however, the group of respondents in this research is only the staff of ITC, and they are not the accurate target group respondents. Some of the staff goes shopping by car, some go by bus, and even many of them walk to the city centre for shopping. In that way, as the sample of the survey is not accurate, the respondents cannot fully representative for the average parking seekers, this survey is only a test survey which cannot give reasonable survey results.

3.2. Tool development

3.2.1. Map-based Contingent Valuation survey questionnaires

Step 1: Design of the conceptual framework.
The main objective of this research is to find out people's willingness to pay for parking lots near to their destination. The research content is separated into 3 parts: ①The basic information of the participants. This part includes the personal information (income, age, gender etc.). ②The parking location choice based on reality situation. Participants were asked to select the general parking lots they usually choose. The attributes of the parking lots are all based on the reality. ③The parking location choice based on hypothetical situations. Participants were asked to choose their preferred parking lots based on different scenarios with different parking fee of the same parking lot. The scenarios do not disobey the real situations. So the results can reflect the impact of different influencing factors to the parking lot choice.

In general, people usually participate in stated preference research based on three kinds of question formulations: ①choice of the preferred option from two or more than two options. ②choice of the preferred option from two options or to state the two options have the same attractiveness. ③choice of the preferred option from two options and to state the preference extent of each option.

This research adopted the first kind of question formulation. Participants were given all parking lots around the city centre to choose. Each parking lot is one of the options. Participants were free to make their choice as close as possible to their actual selections. The main factors discussed in this research are parking fees and walking time from the parking lot to destination.

Step 2: Prepare the maps of the Stated Preference survey
Parking lots with attribute the same with the reality are shown in the map of the second part of this questionnaire. The distribution of the parking lots with parking type and parking tariffs is shown in the figure 5 below.

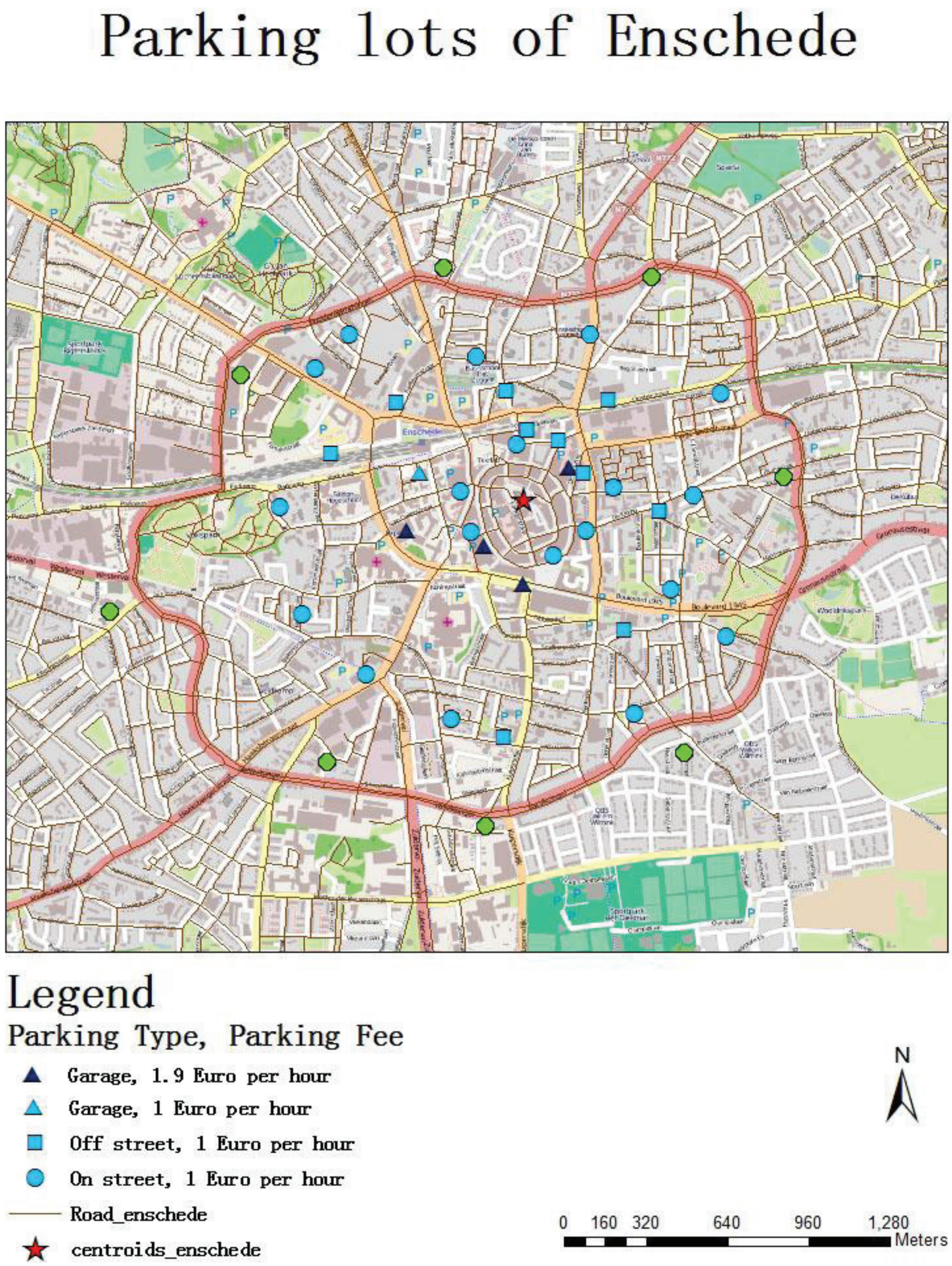


Figure 5 Parking lots with parking type and current parking tariffs

For the third part of this research parking fee has been changed into different levels, other attributes of the parking lots remain the same with the reality. The distribution of the parking lots with parking type and parking tariffs is shown in the figure 6 below.

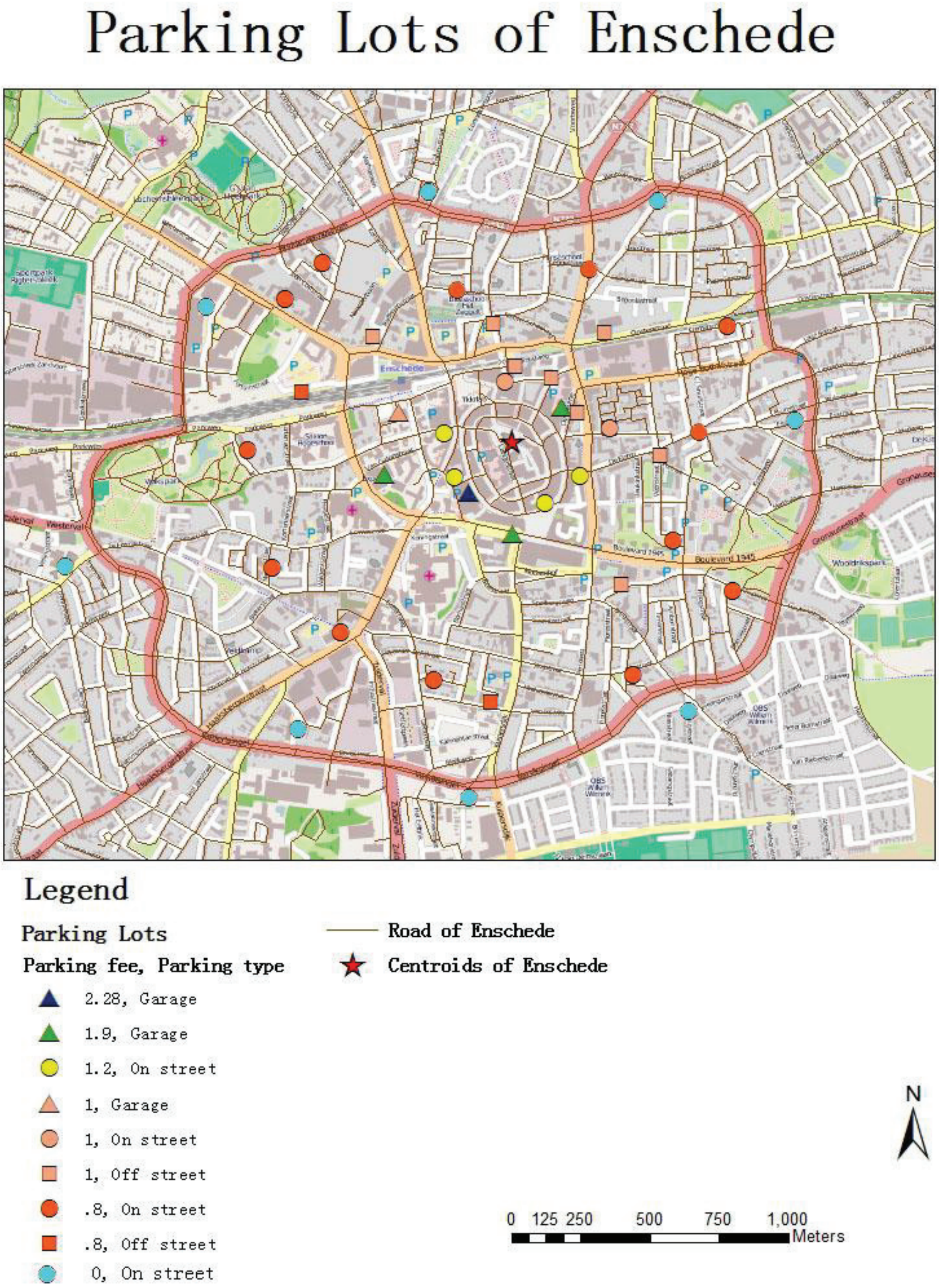


Figure 6 Parking lots with parking tariffs changed

Step 3: Preparation of the attribute table for each parking lot

As designed, parking lot attributes would be displayed directly when participants click the points representing the parking lot on the map. The figure below shows an example of the attribute table.

Figure 7 Attribute table of the parking lot with parking tariffs changed

Step 4: Building the website for the map-based questionnaire

This section consisted of building the website which consists of the welcome page, three parts of the questionnaire, maps, attribute tables, questions and the end page. In addition, the back-end services to save the selections and related questions' answers of each respondent were organized here, and the results gathered together.

The questionnaire of the Stated Preference Approach I, Contingent Valuation Method is built based on HTML language and ASP language. The whole website is created by Static Method. The invoking function of all the points on the map are adopted Static Method. The points are identified by Hot identification method instead of the hyperlink method. The background program of this questionnaire has been separated into three parts; each part is an individual database storing the data collected by a different page. This distinctive design can solve the problem that some participants may interrupt the survey halfway. Paragraphing the data collection process made it possible to maximize the usable data. Data collected by the user interface was submitted by post mode instead of get mode. Because the get method has the Field Limiting and has to use Plain Text Transmit Mode, the post mode which can be unlimited transmitted is a better choice.

3.2.2. Map-based Choice Modelling survey questionnaires

The choice based survey was built-up in 6 steps which are discussed below:

Step 0: Design the conceptual framework.

Step 1: Preparation of the Entry Direction Map.

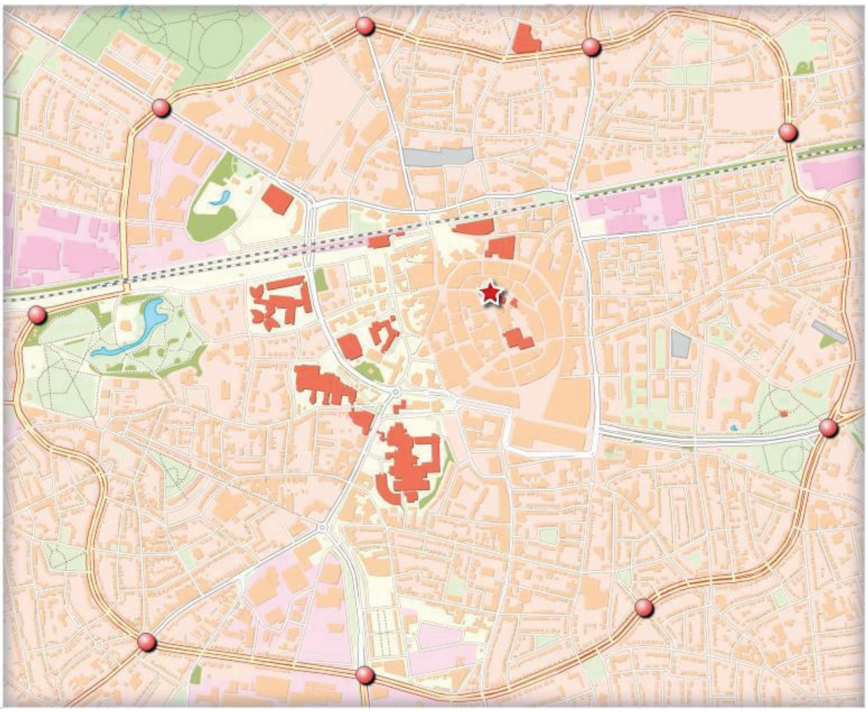


Figure 7 Entry points of Enschede

Step 2: Preparation of information on all parking lots and display of all the parking lots on map.

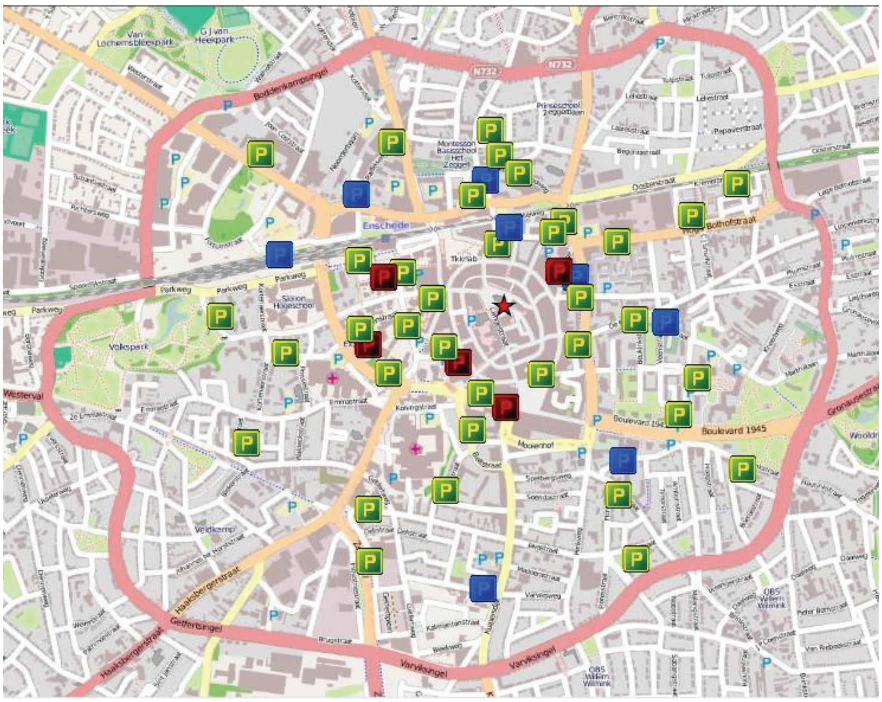
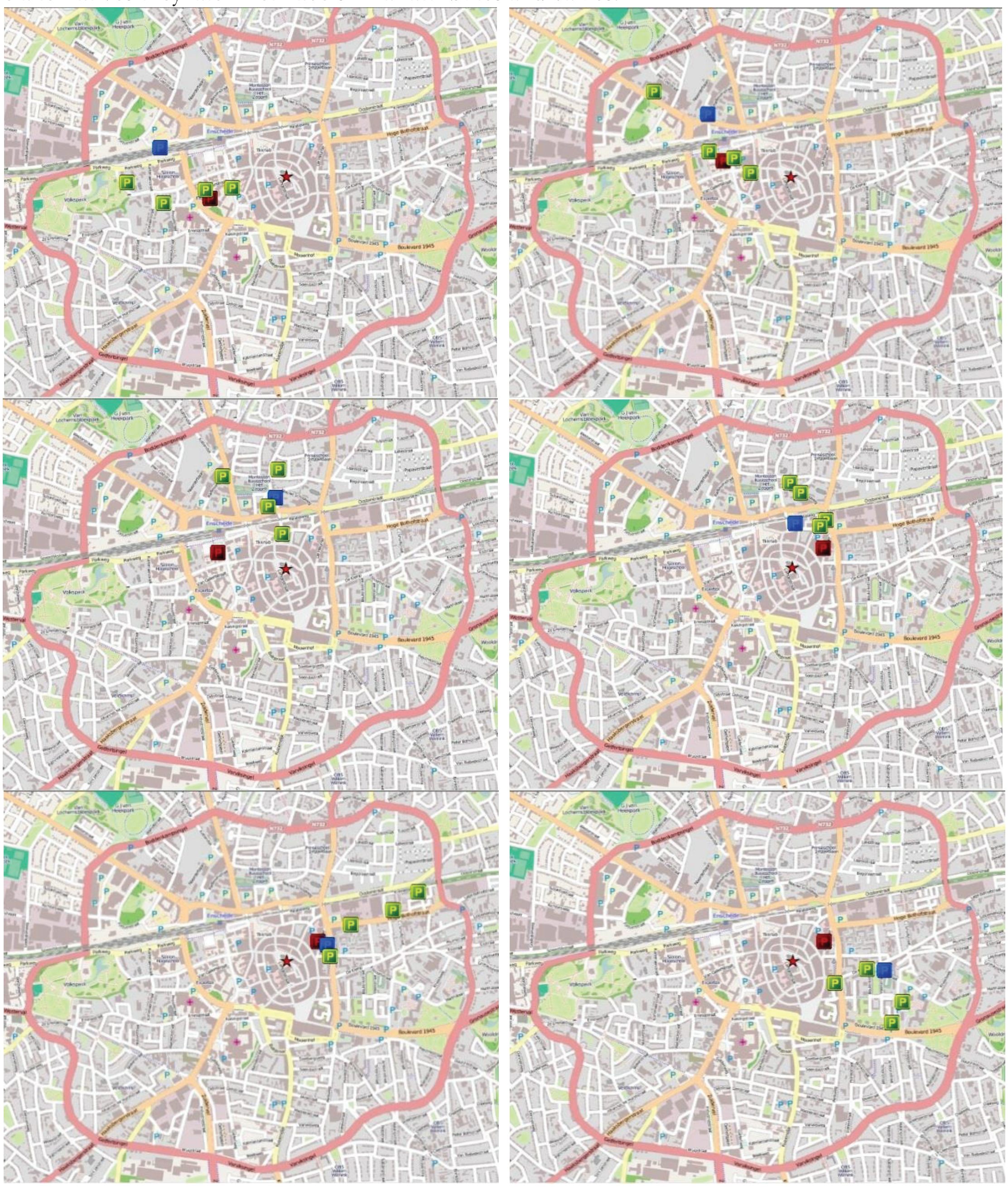


Figure 8 Parking lots of Enschede

Step 3: Preparation of the sub-set parking lots information related to each coming direction point. (using Excel tables)

Step 4: Preparation of each sub-set parking lot map.

The parking lots were selected based on the direction of the entry point and the destination. For each entry point, 6 parking lots were selected from the total parking lots. In order to balance all the sub-sets, for each entry point, the selected 6 parking lots consist of 1 garage parking lot, 1 off-street parking lot and 4 on-street parking lots. The arrangement of parking lots ensured that no matter which entry point participants selected, the alternatives they later met have similar attributes and values.



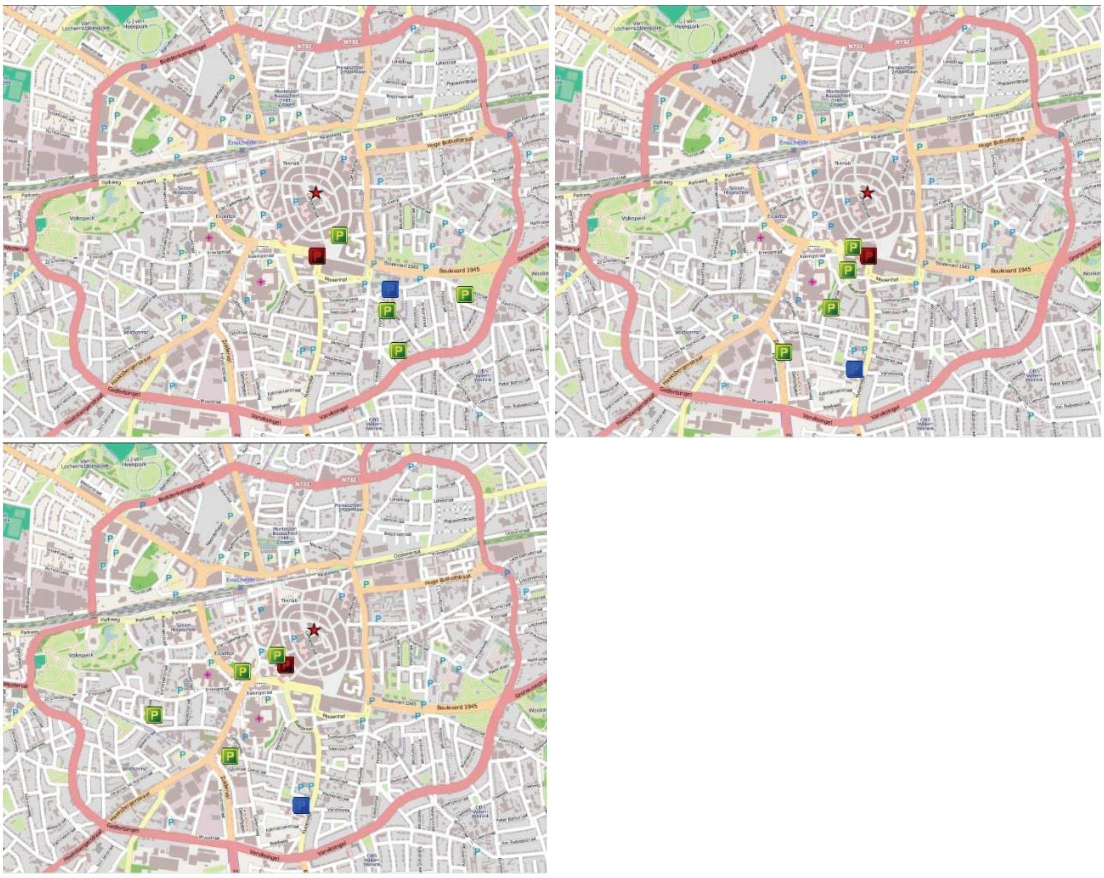


Figure 9 Parking lots of each entry point

Step 5: SQL script: select 4 parking lots of the whole parking lots in the sub-set list for 4 choice sets. Each time there are 4 parking lots are selected from the whole 6 parking lots of the pie based on the choice of the coming direction. If the whole 4 selected parking lots are totally the same with the previous selection, the process of selection will redo for another time. The parking fee attributes of the parking lots are displayed as the changed ones, the changed parking fee equals to the real parking fee multiply by the random distribution of the parking fee change level. Except the attributes of the variable parking fee, the attributes of other variables are all based on the reality.

For example:

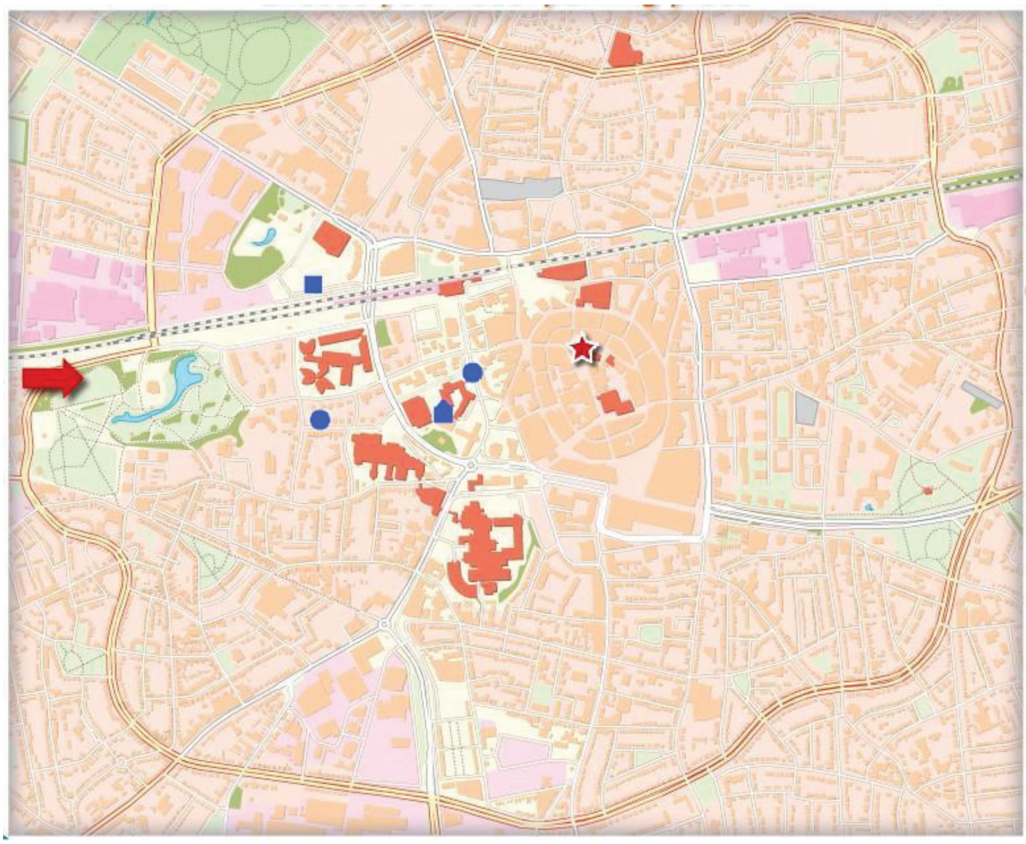


Figure 10 Parking lot choose page after selected the entry point

Step 6: Save the 4 choices of each respondent, and gather the whole results together.
The questionnaire of the Stated Preference Approaches I Choice Modelling Method was built based on HTML language and FLASH language. The main part of the website was all developed by Flash, and the user interface was built with HTML. There was a swf formats file related to the user interface. All the maps, questions, texts and actions were stored in that file.

3.3. Experimental processes of the map-based SP surveys

3.3.1. Experimental processes of the map-based Contingent Valuation survey

To begin with, there was a welcome page telling respondents the hypothesis of the survey questionnaire. People were assumed to be Saturday shoppers going to the city centre of Enschede, they were asked to choose their preferred parking lots based on different scenarios. The figure below shows the welcome page of the map-based Contingent Valuation survey questionnaire.

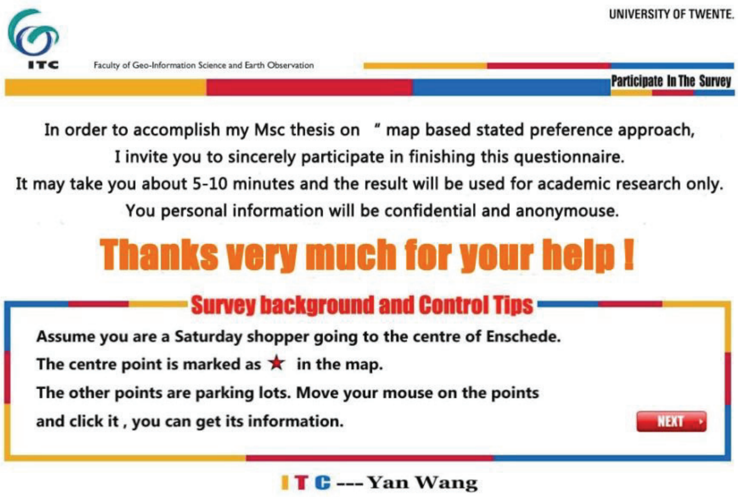


Figure 11 Page 1 of the Contingent Valuation website questionnaire

At the end of the welcome page, a button "next" was provided. After clicking this button, participants entered into the main parts of the questionnaire. The first part reveal preference of parking location choice. Provided was a map of Enschede city centre. The map had many points with different colours showing all parking lots in Enschede. When participants move their mouse on the point and check it, the information about this parking lot would show directly on the page. Participants were asked to choose their preferred parking lots based on the map and parking lots' information, and answer the questions on the right of this page then click the "next" button to turn the page. The figure below shows the first map page of the map-based Contingent Valuation survey questionnaire.

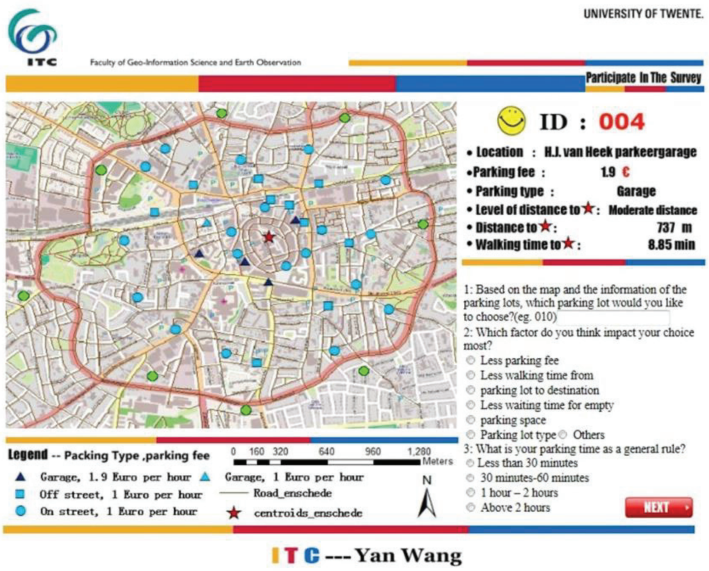


Figure 12 Page 2 of the Contingent Valuation website questionnaire

After clicking the "next" button on Page2, participants enter into Page 3. Page 3 was the most important part of the questionnaire. This page is mainly about the key questions of the Stated Preference Approach. On the left of this page, there is a developed map of Enschede city centre with the changed parking tariffs. The same as Page 2, when participants move their mouse on the point and check it, information about this parking lot would show directly on the page, the difference is that there are 3 scenarios related to this map. Different sharps of the points represent different parking lot types. Different colours of the points show different parking fee of the parking lots. Each colour stands for different parking fees under different scenarios. The figure below shows the first map page of the map-based Contingent Valuation survey questionnaire.

Participants were asked to choose their preferred parking lots based on the map and parking lots' information, for three times, one parking lot for one scenario then click the "next" button to turn into the next page. The figure below shows the second map page of the map-based Contingent Valuation survey questionnaire.

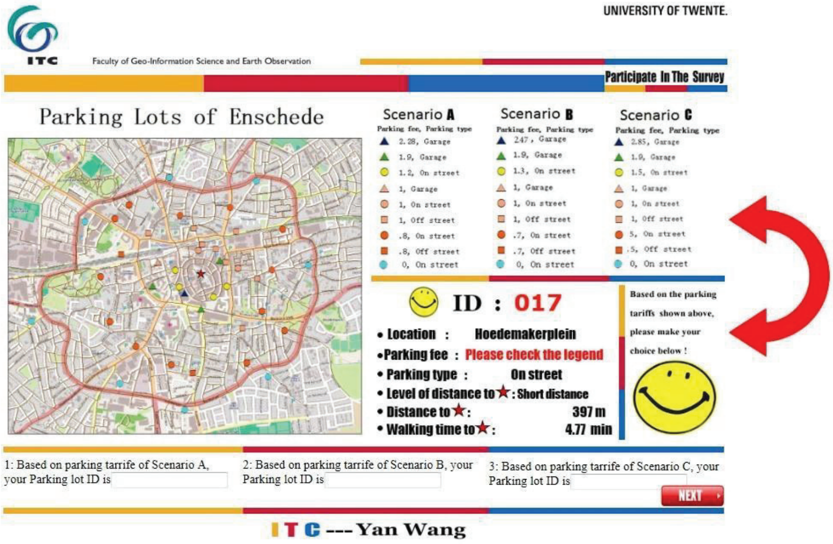


Figure 13 Page 3 of the Contingent Valuation website questionnaire

Then participants enter into the final page of the questionnaire. On this page, participants were asked to fill in some personal information, such as gender, age, etc. The survey questionnaire ends by clicking the "submit" button. The figure below shows the final page of the map-based Contingent Valuation survey questionnaire.

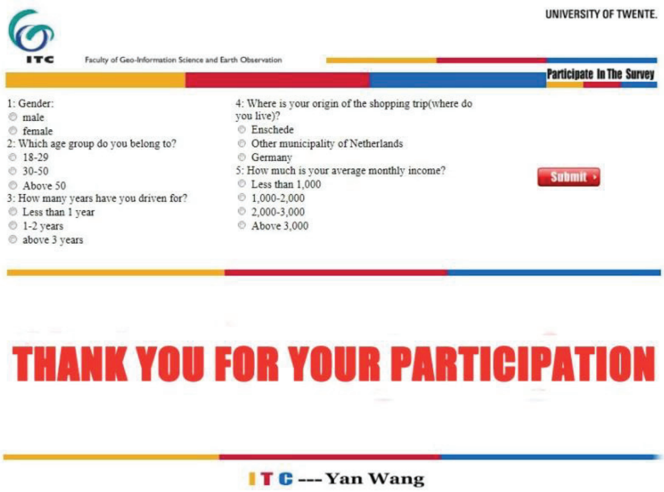


Figure 14 Page 4 of the Contingent Valuation website questionnaire

3.3.2. Experimental processes of the map-based Choice Modelling survey

To begin with, the respondents were asked to enter their personal data. Then they were asked to select the coming direction to Enschede ring based on the entry points on the map. That was an important step to reduce the parking lots represented to participants. The lower number of parking lots is the basic claim of the Stated Preference method.

Figure 15 Page 1 of the Choice Modelling website questionnaire

After the entry points selected, there is a choice-based questionnaire map designed automatically based on the coming direction and the random 4 choices of the full options of this direction. The figure shows the choice-based questionnaire present to each respondent.

Figure 16 Page 2 of the Choice Modelling website questionnaire

The choice-based SP experiment consisted of some SP choice maps, and in each map the respondents were asked, “Which of these parking lots would you choose to assume you are a Saturday shopper going to the city centre of Enschede?” In the figure above, the respondent is asked to fill in 4 choice maps, and in map No. 1 he/she chose an alternative “Parking lot 2”. The candidate parking lots to be chosen on the choice map are called alternatives. Here we have 4 alternatives, “Parking lot 1”, “Parking lot 2”, “Parking lot 3” and “Parking lot 4”.

The combination of alternatives (in this case, “Parking lot 1”, “Parking lot 2”, “Parking lot 3” and “Parking lot 4”) is called a choice set and the name of alternative is called brand. Because the brand name is not shown to the respondents in this case, the case is called “without brand name”, or unlabelled experiment. If it is with brand name, it is called “with brand name” experiment. When the respondents are shown alternatives which belong to the same brand, it is called “in-product” experiment. When shown alternatives which belong to different brands such as this case, it is called “between-product” experiment. Without brand name experiment is always in-product experiment.

Alternatives consist of attributes and attributes’ levels. In this case, the attributes of “Parking type” alternative are “On street parking”, “Off street parking” and “Garage”. The “Parking distance” alternative has 4 attributes, i.e., “From 0 kilometres to 6 kilometres”, “From 6 kilometres to 12 kilometres”, “From 12 kilometres to 18 kilometres”, and “Above 18 kilometres”. The “Parking fee” alternative has 2 attributes, which are “1 euro” and “1.9 euro”. For each alternative, combinations of attributes’ levels are considered and each combination is called “Scenario” (or “Option”). In this case, each Scenario is one parking lot on the map.

In this case, since the number of alternatives is 4, this game is called a multinomial choice game. As the number of alternatives is always the same throughout the experiment, it is called “Fixed choice set design”. The fixed choice set designs are the most common type of SP application in the transportation research.

3.4. Data modelling and analysis

3.4.1. Model structure for CV survey

To do the CV analysis the various options which people choose based on different scenarios have the same attraction for them. So the time value of parking behaviour is:

$$\text{VOT} = \frac{\Delta Cost}{\Delta Time}$$

The distance from parking lot to destination can be represented both by walking time and exact distance. The distance value of parking behaviour is:

$$\text{VOD} = \frac{\Delta Cost}{\Delta Distance}$$

The main idea of this method is that the choice of different scenarios has the same economic value. As the total economic value is same under different scenarios, the difference between the cost and the difference between the time and distance can be used to calculate the VOT and VOD.

3.4.2. Model structure for CM survey

The stated choice data from the SP survey was analysed using a most-used model for processing data from choice experiments in transportation research (Blamey, Bennett, Louviere, Morrison, & Rolfe, 2000), which is random utility model. The main idea is giving each choice a “Utility Value”. The “Utility Value” is calculated based on the cost and quality of service stemming(Willumsen & de Dios Ortuzar, 1985). In this model, travel decision makers are assumed to get the utility maximization between the advantage of using a given mode and the uncertainty of using this given mode based on the “Utility Value”. A random utility model in the form of binary logit has been used in this study. And this study uses the maximum likelihood method to estimate the binary logit models. The specified random utility model estimated in this study is expressed as:

$$U_{bn} = V_{bn} + \varepsilon_{bn}$$

Where, n is an index for individuals; b is an index for parking lots (b= A B C or D, because each scenario comprises four alternative parking lots); U_{bn} = the utility of choosing the selected parking lot for an individual n; V_{bn}= the systematic utility component of choosing the parking lot; and the random error term ε_{bn}= the non-observable utility component of choosing the parking lot, which is assumed to be identical and independently standard Gumbel distributed across alternatives and observations. The systematic part of utility depends on the attributes considered in the study and, in this case, is given by the equation:

$$V_{bn} = \sum \beta_{bk} X_{bkn}$$

Where, V_{bn} = the systematic utility component of choosing the parking lot; β_{bk} = the utility coefficient associated with attribute X_{bkn} of choosing the parking lot; X_{bkn} = represents a vector of explanatory variables specific to parking lot b and individual n; and k = the k^{th} attribute of the parking lot. The systematic utility functions of the alternatives are linear combinations of the parking lots service quality attributes, as shown in the following expression:

$$V_{pl\_b_i} = \beta_{wt\_b_i} WT_{pl} + \beta_{fee\_b_i} FEE_{pl} + \beta_{pt\_b_i} PT_{pl}$$

Where, $V_{pl\_b_i}$ = systematic utility component of the parking lot per distance level; WT_{pl} = walking time from the parking lot to destination (one way); FEE_{pl} = parking fee of the parking lot; PT_{pl} = parking type of the parking lot; $\beta_{wt\_b_i}$ = coefficient associated with attribute walking time, specifically for each distance level based on the O-D distance matrix ring; $\beta_{fee\_b_i}$ = coefficient associated with an attribute parking fee of the parking lot, specifically for each distance level based on the O-D distance matrix ring; $\beta_{pt\_b_i}$ = coefficient associated with the attribute parking type of the parking lot, specifically for each distance level based on the O-D distance matrix ring; and b_i= O-D distance matrix ring i where i = short distance level; moderate distance level; and long distance level.

The short distance level consists of parking lots which walking time from the parking lots in the centre of Enschede is below 6 minutes. The second level is moderate distance level which walking time is from 6 minutes to 12 minutes. The last level is long distance level which walking time is from 12 minutes to 18 minutes.

As this was an unlabelled design, no socio-economic variables have been introduced, and the intercept has not been considered when designing the models(Rose, Hensher, & Greene, 2005).

4. MODEL RESULTS OF MAP-BASED STATED PREFERENCE SURVEY APPROACHES

This chapter discusses mainly discussed the results of the Map-based Contingent Valuation survey and the Map-based Choice Modelling survey. The discussion consists of point of view of the respondents, data calculation, statistical validity discussion and further applications of the results.

4.1. Contingent Valuation survey results

4.1.1. Respondents

As discussed above, only UPM students of ITC were selected to participate in the map-based Contingent Valuation survey. The questionnaire survey was implemented by sending email to the sample group. There are 38 participants finished the questionnaire completely. So there are 38 pieces of complete and available information has been selected during the survey.

Descriptive analysis results of the survey data show relatively good representation of male and female respondents. The classifications of the sample data are based on different attributes. All groups based on all classification are represented in the table below. According to the classification based on "the reasons for selections", the most influencing factor of people's parking lot choice is the walking time from the parking lot to destination. This implies that people are very sensitive to distance. So it is very important to analyse the economic value of distance from parking lot to destination. The main objective of this approach is to analyse WTP (Willingness to Pay) of short distance from parking lot to destination.

Table 6 Classifications of samples based on the Reasons for selections

Reasons for selections	Less parking fee	Less walking time from parking lot to destination	Less waiting time for empty parking space	Parking lot type
Number of Samples	5	29	2	2
Percentage	13.2%	76.3%	5.3%	5.3%

The table below shows the classification of samples based on the gender. There are 15 females and 23 male participated the map-based Contingent Valuation survey. There is no absolute predominance of each gender.

Table 7 Classifications of samples based on the Gender of respondents

Gender of respondents	Female	Male

Number of Samples	15	23
Percentage	39.5%	60.5%

The table below shows the classification of samples based on the age of respondents. The vast majority of the respondents belonging to this group are under 50 years old. The sample covers all the age group, but because the sample group are only from ITC, it is not fit the actual age group of the Saturday shoppers to Enschede.

Table 8 Classifications of samples based on the Age of respondents

Age of respondents	18~29	30~50	Above 50
Number of Samples	21	15	2
Percentage	55.3%	39.5%	5.3%

The parking time classification is shown in table 9. There are 10.5% participants parking their cars less than 1 hour, 28.9% participants parking their cars from 1 hour to 2 hours and 60.5% participants parking their cars more than 3 hours. As most people parking their cars longer than 3 hours, the parking fee variable becomes more important to the parking location choice.

Table 9 Classifications of samples based on the Parking time

Parking time	**Less 1 hour**	**From 1 hour to 2 hours**	**More than 3 hours**
Number of Samples	4	11	23
Percentage	10.5%	28.9%	60.5%

The table below shows the classification based on the Home location of respondents. Most people coming from the Netherlands.

Table 10 Classification based on the Home location of respondents

Home location of respondents	**Enschede**	**Other municipality of Netherlands**	**Germany**
Number of Samples	24	12	2
Percentage	63.2%	31.6%	5.3%

Based on the table 11, more than half of the respondents have the income between 2000 to 3000.

Table 11 Classifications of samples based on Income of respondents

Income of respondents	**Less than 1000**	**1000~2000**	**2000~3000**	**More than 3000**

Number of Samples	3	10	20	5
Percentage	7.9%	26.3%	52.6%	13.2%

4.1.2. SPSS for CV survey data analysis

The data collected from the map-based Contingent Valuation survey are calculated by SPSS. The mean value, minimum value, maximum value and standard deviation value are calculated for both the VOD and VOT. The results were calculated and shown in tables below. The VOD is 1.55 Euro per kilometre. The standard deviation of the result is 0.54 which is an acceptable value. It means the result of VOD is valid.

Table 12 SPSS analysis result of VOD

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Mean	114	.00	1.80	1.5544	.53681
Valid N (listwise)	114				

The mean VOT is 0.13 Euro per minute. The standard deviation of the result is 0.04 which is a very good value. It means the result of VOD is very accurate. The VOT value reflects the economic value of the walking time, which can be used to balance parking tariffs and distance from parking lots to destination. When policy makers want to relieve the pressure of insufficient parking lots, the VOT value can be used to guide policy makers solve this problem through changing the parking tariffs.

Table 13 SPSS analysis result of VOT

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Mean	114	.00	.15	.1295	.04473
Valid N (listwise)	114				

4.1.3. Statistical validity

To test the validity of the results, a statistical description is calculated using the SPSS. Each line in the Table 14 represents the result of one scenario. For Scenario A, the minimum VOT is 0 Euro per minute, the maximum VOT is 0.15 Euro per minute and the mean VOT is 0.1368 Euro per minute. The standard deviation is used to measure how well the mean value represents the data. Small standard deviations indicate that data points are close to the mean value, and a large standard deviation indicates that data points are distant from the mean value. The standard deviation value of Scenario A is 0.03917, this means that the difference between all the data is small, so the mean value is valid. The same with Scenario A, the standard deviation values of both Scenario B and Scenario C are less than 0.05, so the mean value of each scenario is valid. The total VOT mean value of 0.13 Euro per minute is calculated by the three mean VOT values.

Table 14 Descriptive statistics of VOT

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SD	38	.00	.15	.1368	.03917
SD2	38	.00	.15	.1316	.04415
SD3	38	.00	.15	.1202	.04980
Valid N (listwise)	38				

The same with the VOT calculation, a descriptive statistic is calculated from VOD value. Each line in the Table 15 represents the result of one scenario. For Scenario A, the minimum VOD is 0 Euro per kilometre, the maximum VOD is 1.8 Euro per kilometre and the mean VOD is 1.6421 Euro per kilometre. Also, to test the validity of the VOD value, the standard deviation is represented. The standard deviation of Scenario A is 0.46998, it is less than 0.5. Although the result is bigger than the standard deviation value of VOT, it is still acceptable confirming validity of the VOD value is confirmed. The same with Scenario A, the VOD values of both Scenario B and Scenario C are also confirmed as valid.

Table 15 Descriptive statistics of VOD

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SP1	38	.00	1.80	1.6421	.46998
SP2	38	.00	1.80	1.5789	.52974
SP3	38	.00	1.80	1.4421	.59758
Valid N (listwise)	38				

4.1.4. Comparison of VOT and VOD with other studies

The value of time (VOT) has been studied extensively in recent years. In most of the researches, VOT is done for car travel. The travel time in those researches is car travel time, but in this thesis the time we studied is walking time. However, there are some researches discussed the time of walking time within the whole car travel, which can be used for reference. A study which examined the value of travel time and travel time reliability has been set up in 2012(Carrion & Levinson, 2012). In that research, the values of time of different transport modes are all calculated, the value of time of car drivers is comparable with this research. The time calculated in this research consists of both the driving time and the walking time from the parking lot to destination. For that experiment, the function used to estimate the model is:

$$\text{Utility} = \text{TimeCoeff} \times (\text{Time\_Value}) + \text{CostCoeff} \times (\text{Cost\_Value})$$

The VOT value calculated with this model is 7.58 Euro per hour, which equals to 0.126 Euro per minute. There is another study discussed the value of time in the Netherlands(Tseng & Verhoef, 2008). In this research, the VOT within different period has discussed separately. A conventional multinomial logit (MNL) model and a mixed logit (ML) model have been mutually combined to analyze the VOT. The mean VOT of the period related to this research is 6.63 Euro per hour, which equals to 0.11 Euro per minute. Comparison of the VOT value of 0.1368 Euros per minute calculated in this research with VOT in previous research shows that it is within the acceptable scope thus ascertaining its validity.

4.1.5. Further application of CV results

As discussed above, according to Gemeente Enschede (2011), Enschede is facing two parking problems in relation to the imbalance between supply and demand of parking facilities. One of the problems is surplus parking at certain locations, especially in residential areas, whilst the other is the insufficient parking at certain locations especially during the peak hours resulting in demand spilling on streets, adjacent properties or neighbourhoods especially in the city centre.

It is feasible to balance parking demand and supply through changing parking tariffs. By raising parking tariffs in the insufficient parking locations and lowering parking tariffs of the surplus parking locations to balance the utility of parking lots at different locations. The change of the parking tariffs can be calculated by the VOT. First calculate the difference of distance from the parking lot to destination parking between parking lots, then use the result of VOT to change the value of the distance into the amount of the parking fee to get utility balance. These will be addressed in more detail later in this section 4.3.

4.2. CM results

4.2.1. Respondents

The descriptive analysis results of the survey data (see Table 16) show relatively good representation of all entry points. However, the entry point 1, entry point 4, entry point 8 and entry point 9 are selected most. Each of these four occupies a particular place in the survey.

Table 16 Classifications of samples based on the Entry points

Entry point	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7	NO.8	NO.9
Number of Samples	7	2	2	7	4	5	1	7	7
Percentage	16.7%	4.8%	4.8%	16.7%	9.5%	12%	2.4%	16.7%	16.7%

The origins of the assumed shopping trips are the home location of the respondents. The distribution of the origins is shown below in table 17. Home locations can be separated into three types. 35 of the respondents live in Enschede, 6 in another municipality of the Netherlands and only 1 of the respondents is from Germany.

Table 17 Classifications of samples based on the Home location

Home location of respondents	Enschede	Other municipality of Netherlands	Germany
Number of respondents	35	6	1
Percentage of the total data	83.4%	14.3%	2.4%

4.2.2. Biogeme for SP survey data analysis

Results from all models show that the coefficient of the parking fee variable is negative and highly significant, reflecting a preference for cheaper parking fares. The coefficient of the distance from parking lot to destination variable is negative and shows a significant aversion to walking for a long time after parking cars. The parking lot type parameter has a positive sign, as expected, and indicates that trip makers prefer parking in a high quality environment. However the coefficient is not highly significant.
By using walking time to represent the parameter of Distance from Parking lot to destination, the result of the Biogeme is shown in table 18. The linear-in-parameter expression of the utility of the Table 18 model is:

$$U_{PL} = ASC_1 \times 1 + \beta_1 \times P\_F + \beta_2 \times P\_D + \beta_3 \times P\_T$$

U_{PL} : The Parking Lot choice of the respondent
β_1 : The parameter of the Parking Fee variable
P_F : The Parking Fee variable
β_2 : The parameter of the Distance from Parking lot to destination variable
P_D : The Distance from Parking lot to the destination variable
β_3 : The parameter of the Parking lot type
P_T : The Parking lot type variable

Table 18 Overall Models Based on Total Sample

Attribute	Coef.	t - test	p - value
Parking Fee	-0.504	-2.24	0.02
Distance from Parking lot to destination(walking time)	-0.272	-6.51	0.00
Type of Parking lot	0.433	1.57	0.12
No. of estimated parameters	6		
No. of estimated parameters	167		
Init. log-likelihood	-231.511		
Final log-likelihood	-190.031		
Likelihood ratio test	82.961		
Rho-square	0.179		

As it is not clear whether the variable type of parking lot greatly impact the preference of trip makers and utility of the parking lot, so the utility analysis without taken the type of parking lot is done below. If the type of parking lot is not taken into consideration and only consider the relationship between parking lot choice with the Parking Fee variable and the Distance from Parking lot to destination variable, the linear-in-parameter expression of the utility should be like this:

$$U_{PL} = ASC_1 \times 1 + \beta_1 \times P\_F + \beta_2 \times P\_D$$

U_{PL} : The Parking Lot choice of the respondent
β_1 : The parameter of the Parking Fee variable
P_F : The Parking Fee variable
β_2 : The parameter of the Distance from Parking lot to destination variable
P_D : The Distance from Parking lot to the destination variable
The same with the previous model, the parameter of Parking Fee variable is negative, reflecting a preference for cheaper parking fares. The parameter on the Distance from Parking lot to the destination variable is also negative and shows the preference for a shorter walking distance after parking their cars.

Table 19 Overall Models Based on Total Sample (Do not consider the parking lot type)

Attribute	Coef.	t - test	p - value
Parking Fee	-0.412	-1.91	0.06
Distance from Parking lot to destination(walking time)	-0.258	-6.37	0.00
No. of estimated parameters	5		
No. of estimated parameters	167		
Init. log-likelihood	-231.511		
Final log-likelihood	-191.300		
Likelihood ratio test	80.422		
Rho-square	0.174		

4.2.3. Statistical validity

In the software Biogeme, the validity of the result can be confirmed by several parameters: ①The t-test value of the variable needs to be less than -1.96 or greater than 1.96, then the coefficient of the variable is acceptable. ②The p-value of the variable needs to be less than 0.05. ③The attribute of Final log-likelihood should be greater than the attribute of Init. log-likelihood.

For the first result for the overall models based on total samples, the t-test value of the variable Parking Fee is -2.24, the t-test value of Distance from Parking lot to destination is -6.51 and the t-test value of Type of Parking lot is 1.57. The first two are less than -1.96 and the last one is a little less than 1.96. So the final t-test value of the result is acceptable. For the p-value test, the p-value of the variable Parking Fee is 0.02, the p-value of Distance from Parking lot to destination is 0.00 and the p-value of Type of Parking lot is 0.12. As the p-value is better less than 0.09, the total result is acceptable. In this result, the Final log-likelihood is -190.031, it is greater than the attribute of Init. log-likelihood which is -231.511.

For the first result for the overall models do not take the parking lot type into consideration, the t-test value of the variable Parking Fee is -1.91, the t-test value of Distance from Parking lot to destination is -6.37. The first two are almost less than -1.96. So the final t-test value of the result is acceptable. For the p-value test, the p-value of the variable Parking Fee is 0.06, the p-value of Distance from Parking lot to destination is 0.00. As the p-value is better less than 0.09, the total result is acceptable. In this result, the Final log-likelihood is -191.300, it is greater than the attribute of Init. log-likelihood which is -231.511.

Based on the analysis of the two results, both of them are valid. However, as the sample is not selected according to the real research sample group, even the results are valid in the technological point of view, the results still cannot directly use to solve practical problems of parking in Enschede.

4.2.4. Further application of the CM results

From the results of software Biogeme, it is possible to know how the influencing factors impact parking location choice based on the coefficients of the factors in the utility function. With the analysis of the parameter of the variables, we get the conclusion that trip makers prefer cheaper parking fees of the parking lot, a significant aversion to walking for a long time after park their cars and significantly parking in a high quality environment.

However, besides getting the result of how the influencing factors impact parking location choice, we can also calculate the utility of each parking lot. With the utility function below, and the actual value of each factor of the particular parking lot, the utility of each parking lot can be calculated.

$$U_{PL} = -0.504 \times P_F - 0.272 \times P\_D + 0.433 \times P\_T$$

By showing the utility of all the parking lots in Enschede, the surplus parking location and insufficient parking location are explicitly presented on the map. This can be used for the government to solve the parking imbalance of Enschede

As show in the legend of the map "utility of the parking lot in Enschede", the utility of the parking lots are classified into three levels, which are low utility, medium utility and high utility. The utility classification thresholds are based on the utility range of all the parking lots. The utility ranges are distributed equally among them into three levels. The range of the high utility level is from -2.3 to -0.9. The range of the medium utility level is from -3.4 to -2.3. The range of the low utility level is from -3.4 to -4.9. And the high utility parking lots are shown with biggest points, the medium utility parking lots are shown with the medium size points and the low utility parking lots are shown with smallest points on the map.

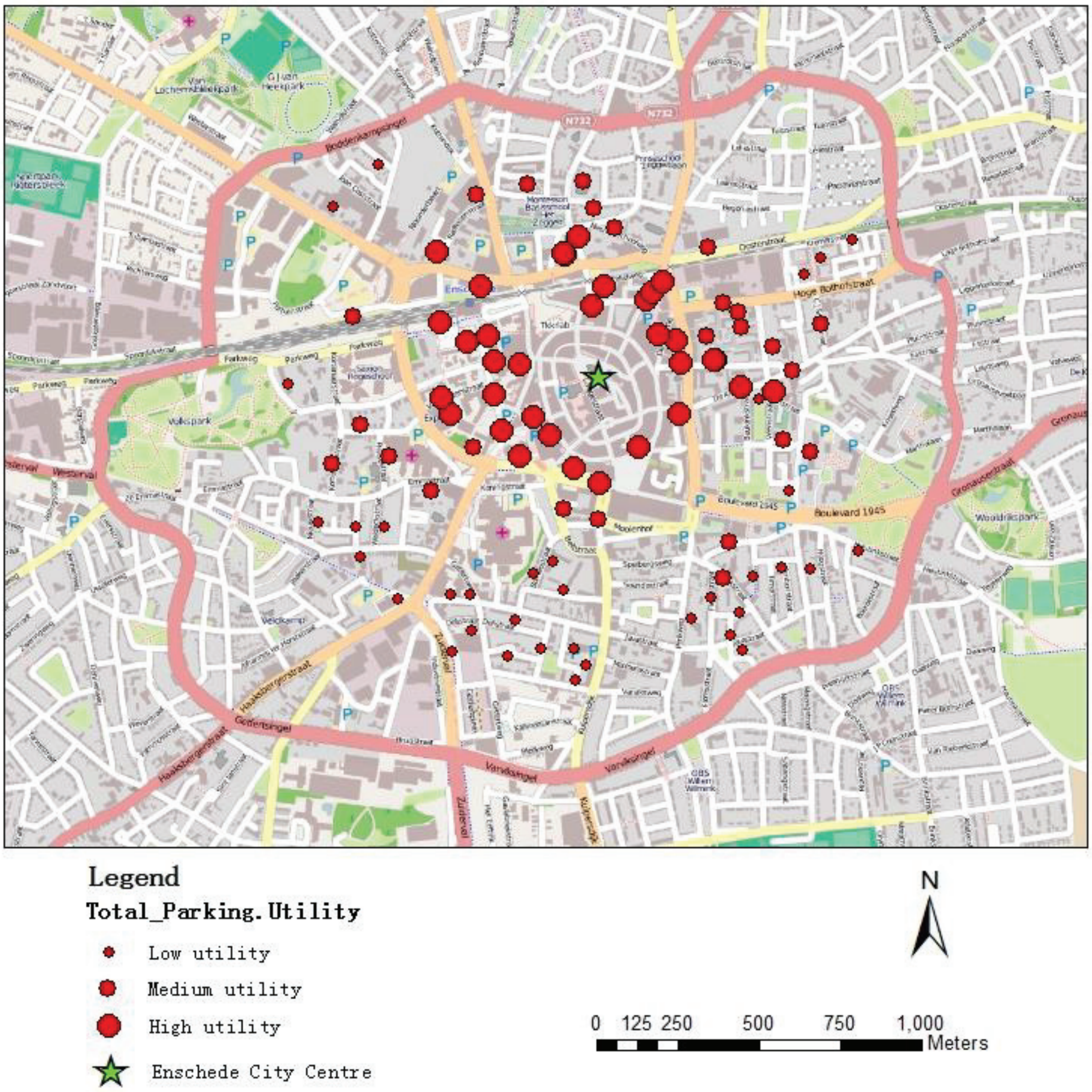


Figure 17 Utility of parking lots in Enschede

4.3. Comparing CV and CM results

The contingent valuation method mainly researches the willingness to pay for a shorter walking distance or a shorter walking time. The objective is to find out the economic value of the uneconomic factors. With the economic value of the uneconomic factors, we can translate all uneconomic factors into economic value, then calculate and analyse the alternatives in terms of straight economics. From that point of view, it is easier for planners to regulate and control the parking situation.

The Choice modelling survey mainly focuses on using the parameters to represent the utility of the parking lot being selected. From the function of the utility and the coefficient of each parameter, we can get the result that how the factors impact the utility of the parking lot being selected. In this research, the parameter of

Parking Fee variable is negative and highly significant, reflecting a preference for cheaper parking fares. The parameter on the Distance from Parking lot to the destination variable is negative and shows a significant aversion to walking for a long time after park their cars. The parameter of parking lot type has a positive sign, as expected, and significantly indicates that trip makers prefer parking in a high quality environment. In general, the negative coefficient means the lower value of this parameter, the higher the utility. In opposite, the positive coefficient means the higher value of this parameter, the higher the utility. Also the coefficient of parameters can represent the interaction between the parameters. Under the same utility, the values of parameters are checks and balances.

To compare and related the CV result and CM result, also

According to the map-based CV survey, the mean VOT is 0.1368 Euro per minute. And the classification of the walking time from the parking lots to the centre of Enschede for the parking lot distance levels is:

- Short distance level: below 6 minutes.
- Moderate distance level: from 6 minutes to 12 minutes.
- Long distance level: from 12 minutes to 18 minutes.

To balance the distance and the parking price, the VOT value is used to calculate the new parking price. For the three distance level, the average of the walking time interval for each level is used to represent the level for calculation. So the short distance level is 3 minutes, the moderate distance level is 9 minutes and the long distance level is 15 minutes. The difference from each level is 6 minutes. To balance the attractive of the parking lots, the price of the different distance level parking lots need to be changed. The price of the short distance level parking lots needs to put up with 0.1368*6= 0.82 Euro. The price of the moderate distance level parking lots remains unchanged. The price of the long distance level parking lots needs to reduce of 0.1368*6= 0.82 Euro.

Then use the utility function obtained from the CM survey to calculate the new utility of all the parking lots:

$$U_{PL} = -0.504 \times P_F - 0.272 \times P\_D + 0.433 \times P\_T$$

The utility of the parking lots of Enschede after the parking fee changed are shown in the figure below. To compare with the original utility map, the utility of the parking lots in Enschede are more balance. The number of both the high utility parking lots and the low utility parking lots decrease, and the number of the medium utility parking lots increases. It means the utility of the parking lots are more balance than without changing the parking tariff. In that way, the distribution of the parking demand will be more balance. The results give reasonable suggestions for the improvement of the parking imbalance of Enschede.

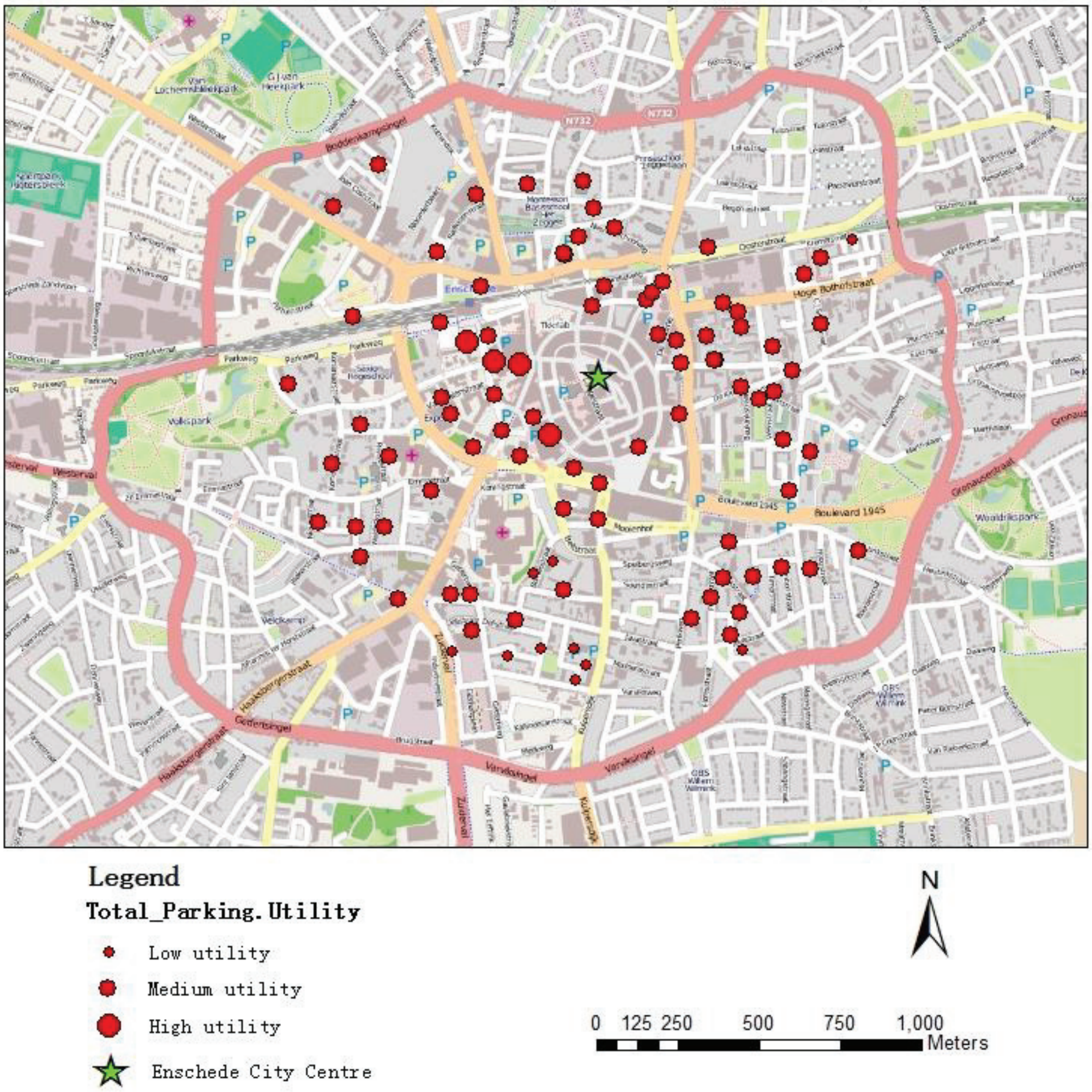


Figure 18 Utility of parking lots in Enschede after parking fee changed

4.4. Pro’s and Con’s of Map-based SP approaches

Advantages:

1. The hypothetical alternative becomes more realistic

   The map-based Stated Preference make the information about the options as clear as possible to the participants. Because the contextual complexity of many transportation decision environments is such that it cannot be translated in textual form without taking the risk of loss of significant information or mischaracterization. The map-based Stated Preference can solve the problem that the verbal representations sometimes cannot convey the true nature of any choice situations.

2. Catch participants' attention

   The map-based Stated Preference questionnaires are mainly based on maps, using the base map and points on the map to represent the information about the options. This kind of questionnaire is quite different from the traditional ones. The new developed type of questionnaire can easily catch participants' attention. The Inquisitive Minds will attract most of the people receiving survey invitation. So the response rate can be higher than the traditional survey.

3. Reduce the volume of reading

   Because the map-based Stated Preference questionnaires use the map-visualization to provide participants information instead of the textual description. This not only makes the process of information transfer much clearer, but also limits the textual description, lower the total reading time of the survey. Without the long text introduction, the whole questionnaire looks more concise and distinct. Reducing the volume of reading means the response time of the participants for the survey has been reduced. Therefore, most of the participants can finish the survey in 5 minutes and even in 3 minutes. That really lessens the number of the participants who interrupt the survey half way. For data collection, it really helps a lot.

4. Offering more alternatives at the same time

   Normally, in the traditional Stated Preference approach, there are only two alternatives shown to participants. Because if there are too many cards representing alternatives shown to people at one time, it is very easy to make participants confused. But with the high quality visualization, research feedback shows that in the map-based questionnaire survey, four alternatives shown to participants at one time are acceptable.

Disadvantages:

As it was the first time to design and implement a map-based Stated Preference survey coupled with little experience and limited scientific literature available for reference, the following problems and shortcomings were identified.

1. The map-based questionnaire survey attracted too much attention of participants on the maps and playing with the maps. That resulted in the lack of heed or attention to the key point of the survey. Some participants gave feedback without knowing what are the objectives and theme of the questionnaire survey. In that way, if people answered the questions without an explicit motif, the collected data and analysed results may have some deviation. This makes a good introduction and explanation is critical.

2. Information misunderstanding. As the parking lots are displayed on the map, the straight-line distance from the parking lot to destination is immediately accepted by the participants. But based on the O-D metric analysis of the reality road network, sometimes the shorter straight-line distance does not mean the shorter walking time. Although the real walking time is shown to participants, the straight-line distance catches too much attention to influence participants' cognition of distance and final choices.

3. Users identify themselves with the location, so consider more hidden attributes than a purely hypothetical case. People may incorporate other aspects than just the location for example. This comes from two directions. The first one is the map-based questionnaires give people too much information, some of the information is not taken into consideration in this research. The added information influencing the participants' choice can be deleted or ignored in the traditional surveys. E.g. when a location is unsafe, they would know from experience. A standard SP would only reveal travel time, thus not location

indicator. The second direction is some information about the displayed ways of the options may lead to people's particular choice. For example, we use different shape of symbols to represent the different type of parking lots in this survey. The preference of the particular shape may impact people's choice of the parking type. But in a real situation, that will not happen. In summary of the two directions, the map-visualization questionnaires may influence the final results to some extent.

5. LESSONS LEARNED AND POLICY IMPLICATIONS FOR PARKING LOCATION CHOICE IN ENSCHEDE

The objective of this chapter is to conclude the lessons learned from the research and to put forward policy implications for the parking location choice in Enschede. This chapter is separated into three parts. In the first part, the experience and lessons summing up from the research from the view of the factors is described. The second part discusses about experience and lessons learned of the research from the view of the method and the suggestions for creating a representative sample. The final part is about the parking location choice in Enschede.

5.1. Derive the results from the point of view of the factors

For the Contingent valuation method, there are only 2 main factors, which are parking fee and distance from the parking lot to destination that have been analysed and discussed. It is my view that one of the most important requirements of the map-based CV experimental design is that the scenarios presented cover a sufficiently wide parking fee variety in the test across individuals. So how to set up the different parking tariffs of each scenario is the main issue that needs to be solved. The number of scenarios and the attribute levels of the parking fee are the key point of the map-based CV experimental design.

Choice modelling experiments are typically based on selection of alternatives with several attributes entering at a few levels. A practical constraint is that the exercise must be kept within manageable proportions. But the number of attribute levels, number of attribute and numbers of alternatives all impact the number of samples. For example, there are three levels for the attribute of parking fee, three levels of the attribute parking type and as the distance being used is all the actual distances, the level for the attribute distance from the parking lot to destination is a lot. For this reason, the small-scale survey within the scope of the study limited the accuracy of survey results. But in reality, the larger the sample group, the higher the financial expenditure. As the research funding was limited in real research, the factors set of Choice modelling experiments need to weigh and balance again and again.

5.2. Discussion of the methods

5.2.1. Derive the results from the point of view of the method

The feasibility of the map-based Stated Preference approach is acceptable within the scope of the study. First of all, the two map-based Stated Preference survey approach both work well. The Stated Preference Approaches (I) Contingent Valuation Method is mainly used to study the willingness to pay for shorter walking time from the parking lot to destination. Based on data collected by the map-based questionnaire, we finally get the result VOT, which is the economic value of the walking time. The Stated Preference Approaches (II) Choice Modelling Method not only considers the parking tariff variable and walking time from the parking lot to the destination variable, but also takes the parking lot type into consideration. Analysis of the results shows both the factors impacting participants' choice and the interaction among these factors. The well running process and reasonable results embody the feasibility of the two new developed map-based surveys. The experimental surveys in this paper testify these two new developed map-based

surveys run well in the small-scale experiments. But the background data acquisition and data integration system can support a very large number of data. So there is no problem to run these two website survey questionnaire instruments in large-scale experiments.
From the point of view of the methods, there are some elements need to be improved:

1. Enhance the background introduction

The two Stated Preference survey are all putting the map-visualization into the most important position. So during the design of the two surveys, I tried my best to explain the background and hypothesis clear and reduce the textual description part simultaneously. But according to the feedback from the participants, the textual description is obviously not enough. So the background and hypothesis introduction part needs to be improved for further studies.

2. The detailed design of the questionnaire should be more sophisticated

As there is limited experience and reference, some detailed section of the map-based Stated Preference survey are not well-considered. Some participants give me the response that they prefer having a help sign on the website. When they meet some doubt with the questions or the scenarios, a help dialogue box can really help the participant understand the situation and how to answer the question. Other details such as the type of symbols, colour assortment of the maps also needs to be further discussed and improved.

3. Balance the SP theory and map-visualization

For the Stated Preference Approaches I Contingent Valuation Method, the participants commented on too many options that were given to them which sometimes caused difficulties in making a decision. Because there were four attributes of one parking lot, which are street name, distance from parking lot to destination, parking type and parking fee, given to participants at one time, and each choice was selected from a large number of parking lots, it was quite easy to get confused. But this kind of question leads to the opposite problem in the Stated Preference Approaches II Choice Modelling Method. In this survey, based on the Stated Preference theory the number of the options display to participants one time should be similar to the number of attributes. So in the Choice Modelling survey, we set only 4 options for one time choice. But this questionnaire with limited options received opposite feedback. Participants responded that it is difficult to find a high degree of correlation between the options and their exact choice. So how to balance the Stated Preference theory and the number of options is a question to be further investigated.

5.2.2. Suggestions for creating a representative sample

As the size of the sample is closely related to the number of attribute levels, a number of attribute and numbers of alternatives, and based on the attribute levels and number of alternatives, the number of respondents for the actual survey need to be much larger than the test survey.

As the most pressing parking problem is on the Saturdays, the survey is aimed at Saturday shoppers in Enschede. The population of Saturday shoppers of Enschede who make use of parking locations consist of residents of Enschede, residents from other municipalities in the Netherlands and residents from Germany, it was not feasible to set the target group based on trip origins. It is better to set the target group based on the trip destinations.

A suggestion for setting the target group for actual survey is collecting data in two ways. The first one is doing face to face interview around the city centre. As the Saturday shoppers mainly come to the open market and the shops and supermarket around the open market, the face to face survey area can be set around the open market and near the various parking sites. The accurate survey area may be along the major entry street of the city centre. It is better to increase the chance to interview genuine car users using parking sites. And the target group is the people shopping in and near the open market. But it needs huge human and material resources to accomplish data collection of the projects. Also, the number of samples obtained in this way is limited. The interview time for each person consists of survey invitation period, survey introduction period, question answering period and conclusion period. It will spend more than 10 minutes for each participant. To ensure a reasonable number of respondents, it is necessary to find a group of survey interviewers.

The second choice is sending paper invitation with description of the survey and website links on it to the people shopping in the city centre and the parkers parking their car around the city centre. As many shoppers don't come by car, so they are not relevant to the survey. It is better to ask people whether they are coming by cars before send them the survey invitations. These invitation letters can be given at the parking lot entrance of the garage parking lot and the computerized toll machines of on-street parking lots. In order to take the parking seekers using free parking lots into consideration, it is suggested the survey interviewers send paper invitations on some free parking lots along the major entry street of the city centre. This pattern covers a broad scope of people, result in a longer survey time and not guaranteed reversion rate. This method of data collection lowers the reversion rate, because the invitation in the entrance of garage parking lot and the computerized toll machines of on-street parking lots cannot attract people to participant the survey effectively. If it is only a paper invitation which people cannot gain any good from answering it, there will be very little number people spending their time to participant the survey. So it is suggested to solve this problem through two ways. The first one is making the paper invitation letter as attractive as possible, and the other is finding some support from the government planning department to give some good to the respondents.

5.3. Discussion of policy implication

5.3.1. Application in previous study

There is a geospatial analysis of efficiency of the parking system of Enschede had been made last year (Chaturvedi, 2012). In that research, parking supply and parking demand of Enschede had been analysed. For parking demand, the attractiveness of the parking lot, which consists of location characteristics and trip characteristics, is a core research problem. The weightages of these factors used in CommuintyViz model was directly decided by experts from Gemeente Enschede. The experts were given a score of 10, and give each factor a score based on the ranking. So it means that the weightages of the factors were decided based on experiences rather than actual survey results.

The result of this survey can just solve this problem. As the two surveys within the scope of this study are both about the people's parking location preference, the weightages of the factors can be calculated from the coefficients of each factor. So use the factor weightages calculated from actual survey result to replace the weightages decided from experiences can make the previous parking demand model more accuracy.

5.3.2. Application in parking policy in Enschede

The map-based Contingent Valuation survey within the scope of this study is mainly about the willingness to pay (WTP) for a shorter distance from the parking lot to destination. The VOT and VOD calculated from this research can be used to change parking tariffs of different parking lots. As the parking fees of parking lots in Enschede are all almost the same, most people prefer the parking lots closer to the city centre. That causes the imbalance of the parking distribution. It manifests as insufficient parking space at certain locations especially during the peak hours resulting in demand spilling on streets, adjacent properties or neighbourhoods especially in the city centre and the parking excess at certain locations, especially in residential areas. Because the WTP for the shorter distance is not the same for people, it is a feasible choice to balance the parking situation by changing the parking tariffs. By means of higher parking fees of the parking lots close to the city centre and lower the parking fee of the parking lots far away to the city centre redistribute parking demand in order to solve the parking imbalance situation.

The map-based Choice Modelling survey mainly discussed how parking influencing factors impact parking lot choice and how parking influencing factors interact. From the analysis, we can get the result that which factor influences people's choice most, how much different factors influences people's choice. That can be used to analyse the attractiveness of parking lot and give suggestions for parking lot adjustment and site selection for new parking lot. There is a test application to balance the parking lot attractiveness and parking demand by changing the parking tariff of parking lots discussed in chapter 4. By application the survey approach into reality scale survey, the result of the parameter for the parking influencing factors will be more accurate, and the more specific suggestion of parking tariff variation can be calculated.

6. CONCLUSIONS AND RECOMMENDATIONS

The objective of this chapter is to conclude the study and give recommendations. This chapter can be separated into two parts. In the first part, the concluding remarks from the scope of the study are presented as the achievements and limitations of the work. In the second part, some recommendations for improvements within the scope of the study and further research ideas have been discussed.

6.1. Research achievements and limitations

In drawing a conclusion to the study, the research achievements and limitations have been emphasized based on the defined scope of the study.

6.1.1. Research Achievements

Stated Preference approaches are used more and more in various research fields, including transport. Finding an appropriate balance between the limited parking space and the increasing parking demand is an important issue in transport. To study parking preferences and behaviour of residents is a good starting point to solve this problem. There is a lot of experience with the traditional stated preference survey approach being used in parking location choice studies. The main objective of this paper was to develop a new type of Stated Preference method, which is also map-based, and implement the new instrument for a parking location choice study in Enschede. The main achievements of this thesis are composed of three parts:

1) Implementation of a Map-based Stated Preference Approaches I Contingent Valuation Method
A map-based Contingent Valuation questionnaire website was built for this study. This map-based survey measured what the people's willingness to pay for a shorter walking distance from the parking lot to the destination. A website questionnaire is composed of four pages was designed. The first page was a welcoming page and the second page displayed the map and points. Participants were to select points on the map to get the information on the parking lots. All the attributes of the parking lots on this page were consistent with the reality; the third page was the core part of the survey and gave three hypothetical scenarios, and allowed participants make their choice; the final part requested participants to fill in their personal information. Different from the traditional CV survey, the new approach have two innovation points. The first and most important one is using maps, symbols instead of numeric, pictogram to explain the questionnaire to participants. It is much more picturesque and attractive. The other one is using the website questionnaire instead of paper questionnaire. This innovation point makes both the survey implementation and the data analysis convenient and fast.

2) Implementation of a Map-based Stated Preference Approaches II Choice Modelling Method
Another website was built for the map-based Choice Modelling Method. This map-based questionnaire was designed conceptually based on Stated Preference theory, and was an even more concise one. This questionnaire was implemented in a Flash map design, so all the information and options were displayed on one page only and were spatial, while the user interface was succinct and clear. Each participant made four stated choices after selecting the direction of entry into the city. The data collected from the website after being summed and integrated was analysed using Biogeme software. The same with the map-based Contingent Valuation method, the map-based Choice Modelling Method also have two innovation points compared with the traditional CM survey.

3) Small-scale implementation to study the parking location preference using the case of Enschede
Although the main objective of this research was to develop Map-based Stated Preference methods, the results of people's preference of the parking lots and the impact of the factors influencing parking location choice were also obtained through a web-based parking location choice survey of Enschede. The case of Enschede was implemented to check the feasibility of the newly developed Map-based Stated Preference approaches. The responses obtained from the survey enabled the analysis of the economic value of the walking time after parking cars. For further analysis, the result can be used to set up the actual survey scenarios. In this research, the hypothetical scenarios are changing the parking tariffs by 20%, 30% and 50%. With the VOD and VOT value calculated in this research, however, the hypothetical scenarios can set around the VOD and VOT. It can improve the survey pertinence. Another achievement is the interaction among parking location choice influencing factors which consists of parking fee, parking type and distance from parking lot to destination. From the result, the utility of each parking lot can be calculated. It can display the parking situation and reflect some problems, also can be used to check the hypothetical parking situation after some parking policy changed.

6.1.2. Research Limitations

Although the new developed map-based Stated Preference models runs well in the implementation of the Enschede case, there are still some limitations of the models. The limitations are composed of three main points.

- **The limitations and problems in setting up the survey.**
  As there is little reference about the map-based Stated Preference survey approach, how to change the text description into map-based description is a problem we meet in the research. Also there are no criteria and rules to follow in designing the maps to depict the scenarios.
  The calibration of the model was not very accurate. Because there were some mistakes in the original data, the information of the parking lots represented to participants was not very exact. Also the data on parking tariffs was average parking fee per day, not the exact parking tariffs as they vary between peak and off-peak periods as well as for daytime and night time. Also during these two map-based questionnaire surveys, the variable of when people park their cars was not taken into consideration.
  Owing to the limited ability of setting up the map-based websites, although with the kindly help of my supervisors and teachers, the final website questionnaires still have some defects. The background process still needs to be improved

- **The limitations and problems in testing the survey**
  Due to the main objective of this research which was to develop a new type of Stated Preference approach and the limitation of study time, implementation of this survey questionnaire was only a small scale one. The scope of the survey was only ITC staff and students, not including residents and real Saturday shoppers. It may cause problem of getting reliable results out of the surveys.
  As there is little reference about the map-based Stated Preference survey approach, there are no criteria and rules to follow to compare and check whether the new map-based approaches are really useful in tying their hypothetical travel scenarios to real-world travel experiences.

- **Further practical limitations:**

For the further practical real-world survey, how to invite parking lot seekers to participate the survey is a problem. The face to face interview will spend too much time and improve the economic costs; however, the sending paper invitation survey method cannot guarantee the response rates. So the sample approach for the further practical real-world survey still need to fully considerate.

6.2. Recommendations

6.2.1. Improvements within the scope of the study

The two main parts of the scope of this study that need to be improved are original data update and to perfect the questionnaire website.

As discussed above, the original data used in this study was not the most updated; even some geographic coordinates of the points have deviation. Although the main objective of this study is a peoples ' preference instead of the real choice, these small deviations may cause some misunderstandings. To improve the instrument, adding links of each parking lot or adding real pictures of the parking lots is a good way. Photos can give participants a very good view of reality, which can really help people make their choice.

Another part which can be improved is the website setting up. Because the limited time and weak foundation in computer language, the process of setting up the website was not very complete. Both the user interface and background process had a lot of small detail problems which need to be improved.

6.2.2. Further research ideas

The two different types of map-based Stated Preference approach are based on total different theories, one is mainly discussing the economic value of the walking time from the parking lot to destination, the other is mainly analysis the factors influencing participants' choice and the interaction among these factors. In this research, the two approaches are totally separate. Nevertheless the two approaches are not unrelated. So in further research, it may be good to relate and compare these two methods.

The two map-based Stated Preference Approaches were tested based on the case of parking location choice in Enschede, this does not mean that the approach can only be used in this case. Though not being perfect, it may be good to implement these newly developed map-based Stated Preference approaches in other research fields.

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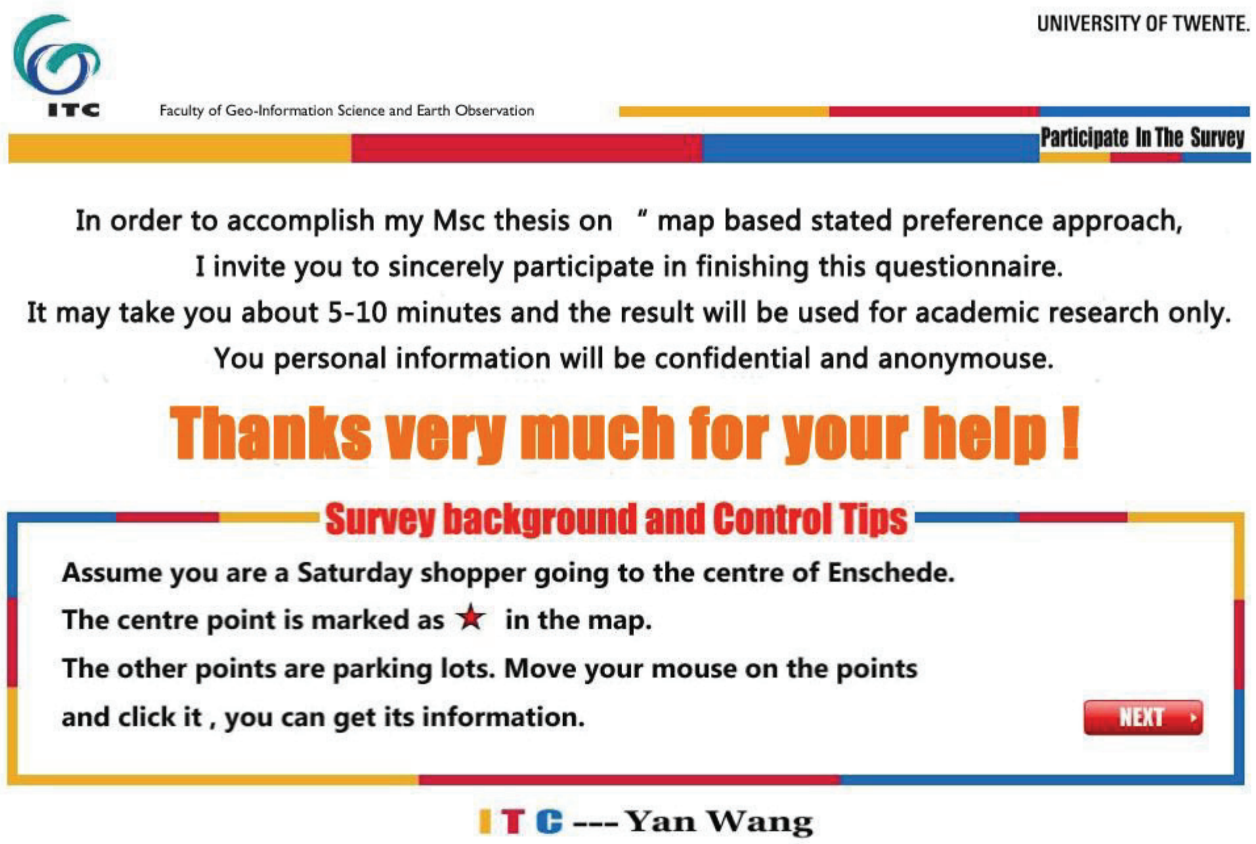
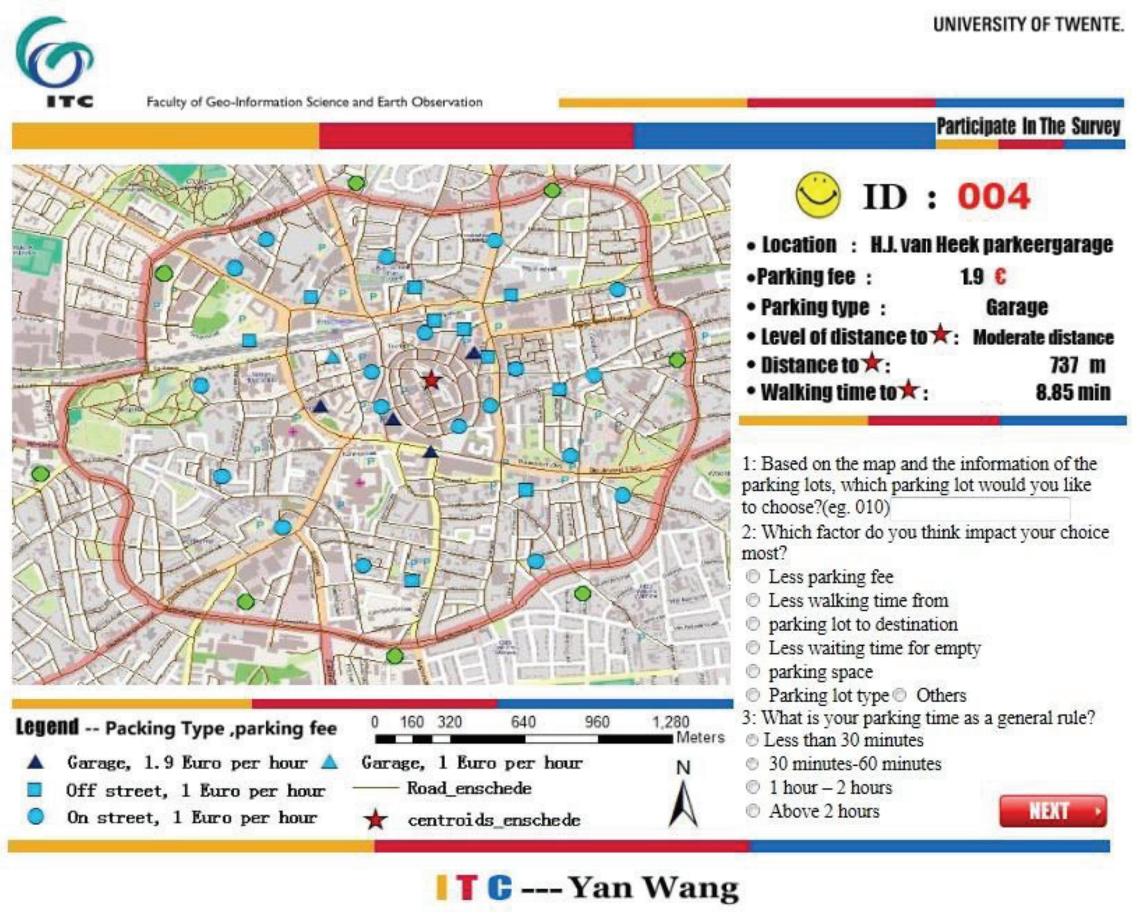
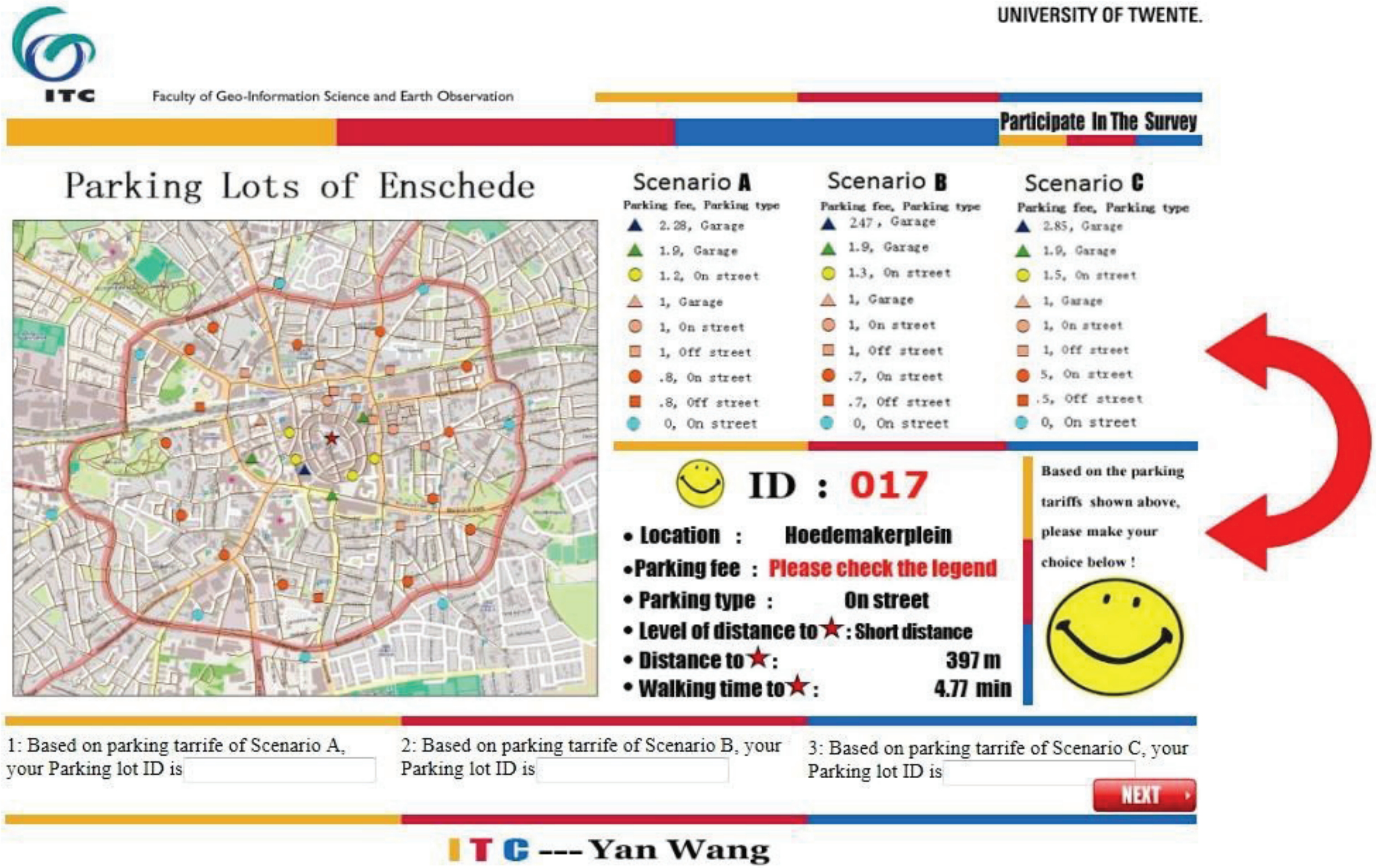
ANNEXURE 1 CONTINGENT VALUATION WEBPAGE QUESTIONNAIRE – PAGE 1



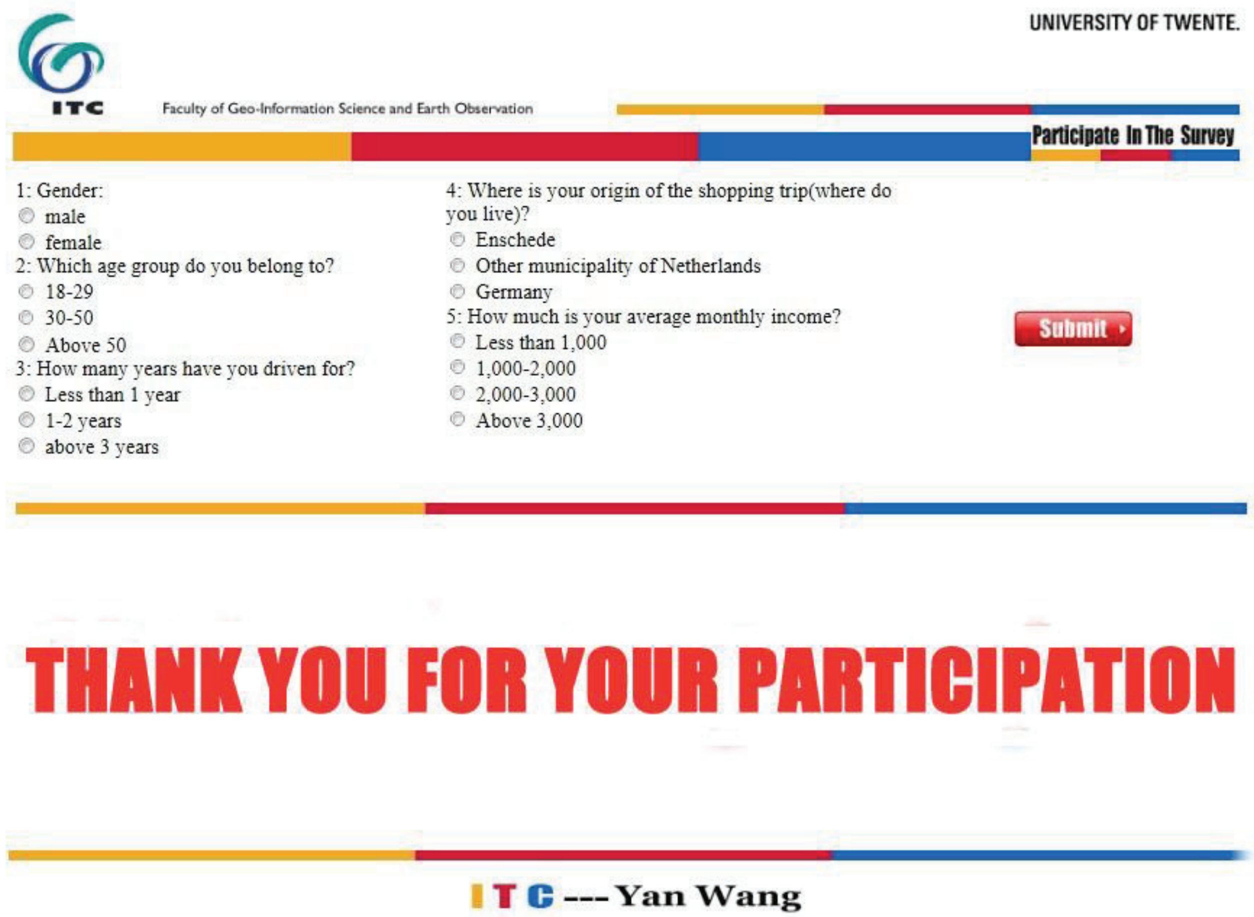
ANNEXURE 2 CONTINGENT VALUATION WEBPAGE QUESTIONNAIRE – PAGE 2



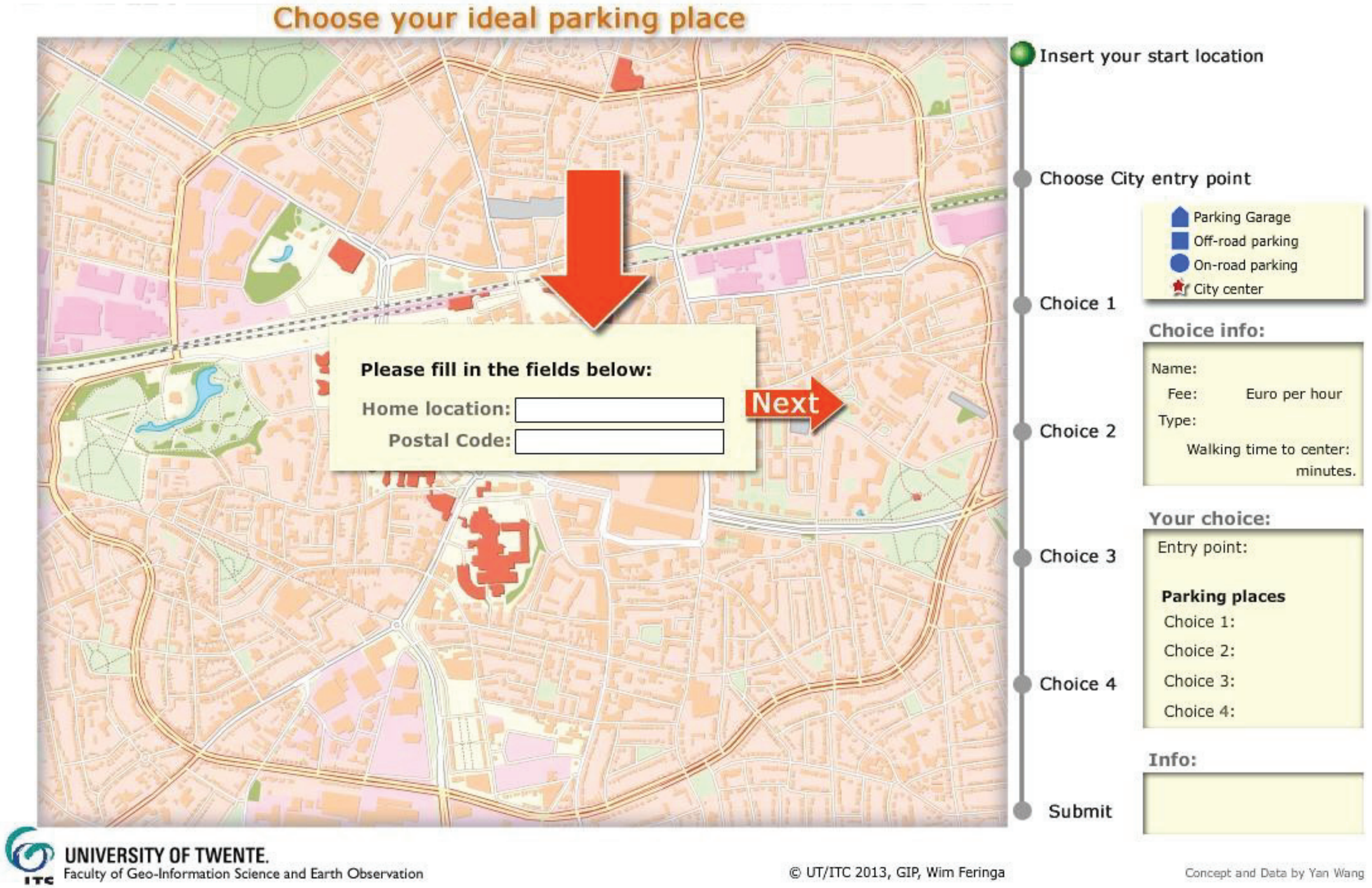
ANNEXURE 3 CONTINGENT VALUATION WEBPAGE QUESTIONNAIRE – PAGE 3



ANNEXURE 4 CONTINGENT VALUATION WEBPAGE QUESTIONNAIRE – PAGE 4



ANNEXURE 5 CHOICE MODELLING WEBPAGE QUESTIONNAIRE – PAGE 1



ANNEXURE 6 CHOICE MODELLING WEBPAGE QUESTIONNAIRE – PAGE 2

ANNEXURE 7 CHOICE MODELLING WEBPAGE QUESTIONNAIRE – PAGE 3

ANNEXURE 8 CHOICE MODELLING WEBPAGE QUESTIONNAIRE – PAGE 4

ANNEXURE 9 MODEL OF BIOGEME

```
[ModelDescription]
"Parking lot choice model"

[Choice]
Choice

[Beta]
// Name Value  LowerBound UpperBound  status (0=variable, 1=fixed)
ASC1      0         -10000         10000       1
ASC2      0         -10000         10000       0
ASC3      0         -10000         10000       0
ASC4      0         -10000         10000       0
BETA1       0         -10000         10000       0
BETA2       0         -10000         10000       0
BETA3       0         -10000         10000       0

[Utilities]
// Id Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 +
... )
  1   Alt1   av1   ASC1 * one + BETA1 * P_F_A + BETA2 * P_D_A + BETA3 *
P_T_A
  2   Alt2   av2   ASC2 * one + BETA1 * P_F_B + BETA2 * P_D_B + BETA3 *
P_T_B
  3   Alt3   av3   ASC3 * one + BETA1 * P_F_C + BETA2 * P_D_C + BETA3 *
P_T_C
  4   Alt4   av4   ASC4 * one + BETA1 * P_F_D + BETA2 * P_D_D + BETA3 *
P_T_D

[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1

[Model]
$MNL
```

ANNEXURE 10 RESULTS OF BIOGEME

```
// This file has automatically been generated.
// 01/31/13 21:42:40
// Michel Bierlaire, EPFL 2001-2008

BIOGEME Version 1.8 [Sat Mar 7 14:36:56 CEST 2009]
Michel Bierlaire, EPFL

   Parking lot choice model

                        Model: Multinomial Logit
Number of estimated parameters: 6
        Number of observations: 167
         Number of individuals: 167
           Null log-likelihood: -231.511
            Cte log-likelihood: -220.638
           Init log-likelihood: -231.511
          Final log-likelihood: -190.031
         Likelihood ratio test: 82.961
                    Rho-square: 0.179
           Adjusted rho-square: 0.153
           Final gradient norm: +5.217e-004
                    Diagnostic: Convergence reached...
                    Iterations: 5
                      Run time: 00:00
           Variance-covariance: from analytical hessian
                   Sample file: CM_4.dat

Utility parameters
******************
Name  Value  Std err   t-test p-val   Rob. std err Rob. t-test Rob. p-val
----  -----  -------   ------ -----   ------------ ----------- ----------
ASC1  -0.786 0.433     -1.82  0.07  * 0.411        -1.91       0.06       *
ASC2  0.00   --fixed--
ASC3  0.308  0.243     1.27   0.21  * 0.244        1.26        0.21       *
ASC4  0.195  0.341     0.57   0.57  * 0.367        0.53        0.60       *
BETA1 -0.504 0.225     -2.24  0.02    0.221        -2.28       0.02
BETA2 -0.272 0.0418    -6.51  0.00    0.0456       -5.97       0.00
BETA3 0.433  0.276     1.57   0.12  * 0.265        1.63        0.10       *

Utility functions
*****************
1       Alt1    av1     ASC1 * one + BETA1 * P_F_A + BETA2 * P_D_A + BETA3 * P_T_A
2       Alt2    av2     ASC2 * one + BETA1 * P_F_B + BETA2 * P_D_B + BETA3 * P_T_B
3       Alt3    av3     ASC3 * one + BETA1 * P_F_C + BETA2 * P_D_C + BETA3 * P_T_C
4       Alt4    av4     ASC4 * one + BETA1 * P_F_D + BETA2 * P_D_D + BETA3 * P_T_D


Correlation of coefficients
***************************
Coeff1 Coeff2 Covariance Correlation t-test   Rob. covar. Rob. correl. Rob. t-test
------ ------ ---------- ----------- ------   ----------- ------------ -----------
ASC3   ASC4   0.0428     0.516       0.38   * 0.0490      0.547        0.36        *
ASC3   BETA3  0.0285     0.424       -0.45  * 0.0274      0.422        -0.46       *
ASC1   BETA1  -0.00368   -0.0378     -0.57  * -0.000820   -0.00902     -0.60       *
ASC4   BETA3  0.0328     0.348       -0.67  * 0.0382      0.392        -0.66       *
BETA1  BETA2  0.000508   0.0541      -1.02  * 0.00132     0.131        -1.05       *
ASC1   BETA2  0.00349    0.193       -1.20  * 0.00207     0.110        -1.26       *
ASC4   BETA2  -0.00823   -0.577      1.27   * -0.0111     -0.663       1.17        *
ASC1   ASC4   -0.0232    -0.157      -1.66  * -0.0210     -0.139       -1.67       *
ASC4   BETA1  -0.00377   -0.0493     1.67   * -0.0147     -0.181       1.51        *
ASC1   BETA3  -0.0977    -0.817      -1.80  * -0.0892     -0.817       -1.89       *
ASC1   ASC3   -0.0162    -0.154      -2.07    -0.0144     -0.143       -2.16
ASC3   BETA2  -0.00342   -0.337      2.23     -0.00431    -0.387       2.19
BETA1  BETA3  -0.0154    -0.248      -2.36    -0.0132     -0.225       -2.45
ASC3   BETA1  -0.00333   -0.0609     2.38     -0.00432    -0.0801      2.37
BETA2  BETA3  -0.00274   -0.237      -2.44    -0.00277    -0.229       -2.52

Smallest singular value of the hessian: 3.81209
```