Car drivers' route choice decisions at unbundled highways and the influence of travel information presented while driving

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This report covers my graduation study done during the master program Construction Management and Engineering (CME) at Eindhoven University of Technology. The study is done with full supervisions of the TU/e and with assistance of Rijkswaterstaat[1]. The focus of this study is on car drivers' route choice decisions at unbundled highways and the influence of travel information presented while driving.

I want to thank the graduation committee for their guidance and support throughout the whole project. Especially Peter van der Waerden, his enthusiasm and knowledge did put me on the next level in creating this thesis.

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Lastly, I want to thank everyone else that contributed to this graduation report. A special word of thanks goes to everyone who filled in the online questionnaire, without these questionnaires there would not have been any results.

I hope that you will enjoy reading this graduation report and that the results will be usefull for current road traffic developments or further research.

As a side note I want to say that the actual knowledge of myself about traffic engineering and road management was fairly low at the beginning of this study. This has increased by a large amount due to the literature study. However, my background in architecture, building and planning could result in different designs compared to fully qualified traffic engineers.

Pieter van Oirschot,
Eindhoven, 2016

[1] Dutch road authority

MANAGEMENT SUMMARY (English)

Traffic congestions are one of the most occurring delays on the Dutch highways. Decreasing traffic congestions is done by several means; one of them is unbundling traffic stream to regional and local traffic. Separating these traffic streams increases the traffic flow and reduces the congestions. Also the provided traffic information while driving has a positive effect on the traffic flow. Road users have several means of receiving traffic information involved with congestions and route alternatives. The means of gathering traffic information along the route can be done by roadside and in-car traffic information systems. Currently the Dynamic Route Information Panel (DRIP) is an important roadside traffic information system, which is used by Rijkswaterstaat (RWS). Because, there is a lack of knowledge regarding the relation between DRIP and in-car distributed traffic information and the behavior of road users towards this information. The current road-side systems need to be compared with the new evolving in-car traffic information systems, and offer insight in the usage of these systems in different on-trip situations.

From literature study more insight was gained in the concept of traffic information managements, different traffic information systems alongside the road and in-car, and the human behavior towards the gained information. The categories of traffic information systems have different kind of visual presentations layouts and purposes. Whereas the dynamic traffic information presented along the road has a general beneficial contribution to the traffic guidance and safety. The in-car systems provide a more personal based information stream with personal beneficial route advice for the road user in question.

The behavior of the road users towards the traffic information presented to them is different for every situation. The reaction of the roads users towards gained traffic information often depends on the skills and their personal view, whereas a general road user does not exist. The opinion of road users towards the perceived usefulness of DRIP(s) is still scattered. The increase of the personal presented information by in-car systems however has a positive effect on the information presentation as well as the guidance by it as found by previous research. However, the in-car systems also cause distraction and possible unsafe traffic situation. Often the behavior and route deviation reasoning depends on the circumstances, cause and time of the delay, the alternative route available, the road designs, and the familiarity of the road users with the surroundings.

With the information gained form the literature study a stated preference experiment was set up to collect data of road user's route choice decision in unbundled highway situations, and the use of different traffic information media. The visualization of the different traffic information media was an important aspect, and had to be comparable with the existing systems. Presenting these systems in a familiar setting is a must; therefore an in-car visualization was made to give the respondent the feel of actually driving the car.

All the attributes are presented by pictorial visualizations to lower the information load and show understandable formats. During the stated preference experiment the respondent has the opportunity to select two different options; the A-route and N-route. A-route is the regional route, and the N-route the route with connections to the local roads.

The data is collected with the use of an online questionnaire. This questionnaire consisted of three different parts. The first part contains questions related to traffic information systems, the second part contains the choice experiment, and the third part contains social-demographic questions.

After the data was collected it got analyzed using a multinomial logit model, which resulted in showing which attributes affect the route choice behavior. There was a difference made between route choice specific attributes and context related attributes. The route choice specific attributes truck traffic at the regional route and exit lanes at the local traffic route have never been researched before and gave new insights in the route choice behavior.

The decisions made by the car drivers in this research sample are differently for several characteristics such as gender, age and driving experience. In general the car drivers base their route choice on the shown travel information while driving on unbundled highways based on the delay times of the route alternative, mostly using this information from the DRIPs. The car drivers make their choices based on their own perception of the circumstances. Taking in mind the route specific attributes such as the truck traffic and the extra stress related driving tasks provided by exit lanes on local roads. For the non-route specific attributes the car drivers mainly base their choice on the time of day (peak-hours) or how often they use a certain road segment, the familiarity. Figure 1 gives the result on the importance of the significant attributes found with this model.

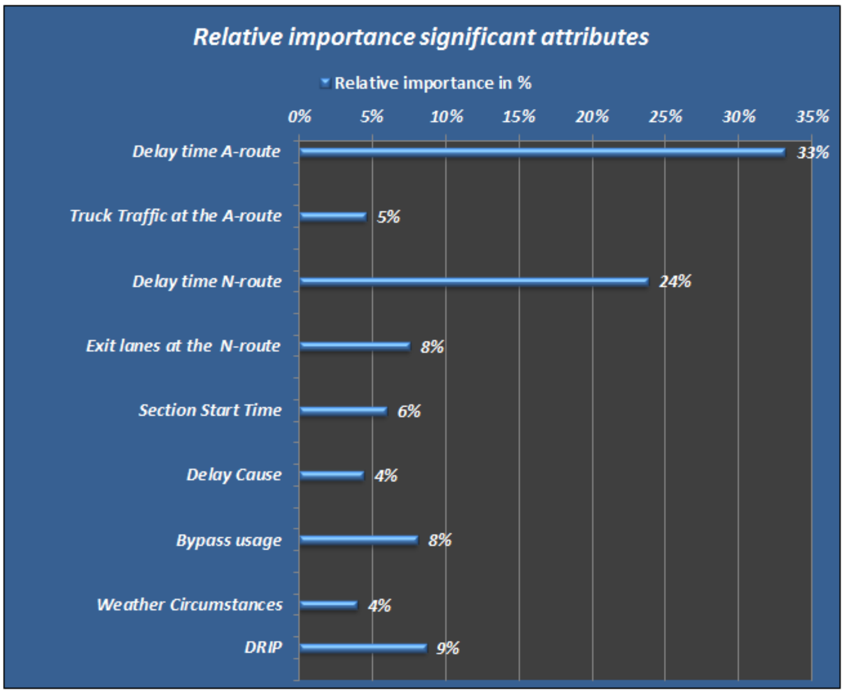


Figure 1 Relative importance significant attributes

A recommendation towards policy makers and governmental parties is to keep investing in the current DRIP systems because they are still heavily used by the road users of today. Even in combination with the other in-car traffic information system which has not been found significant during this research. Further research can be done on the specific in-car traffic information systems such as the smartphone applications.

MANAGEMENT SUMMARY (Dutch)

Verkeerscongesties zijn een van de meest voorkomende vertragingen op de Nederlandse snelwegen. Het verlagen van verkeerscongesties wordt op verschillende manieren gedaan, één daarvan is doormiddel van ontvlechting van de verkeersstromen in doorgaand en lokaal verkeer. Het scheiden van deze verkeersstromen verhoogt de doorstroming en vermindert de files. Ook het aanbieden van verkeersinformatie tijdens het rijden van deze snelwegen heeft invloed op de doorstroming van het verkeer. Weggebruikers hebben verschillende media bronnen voor het ontvangen van verkeersinformatie onder andere bestaande uit congesties en route alternatieven. De verkeersinformatie tijdens het rijden wordt verspreid doormiddel van dynamische verkeersborden aan de kant van de weg en door in-car verkeersinformatiesystemen. Momenteel is het Dynamische Route Informatie Paneel (DRIP) een belangrijk wegkantsysteem dat verkeersinformatie verstrekt. Rijkswaterstaat (RWS) is momenteel aan het kijken of deze relatief duren systemen vervangen kunnen worden. Onderzoek naar de DRIP is vereist, omdat er momenteel een gebrek aan kennis is over de DRIP(s) in combinatie met in-car verkeersinformatiesystemen en het opvolggedrag hiervan. De huidige wegkantsystemen moeten worden vergeleken met de nieuwe nog steeds evoluerende in-car verkeersinformatiesystemen en inzicht bieden in het gebruik van deze systemen in verschillende verkeerssituaties tijdens een trip.

Doormiddel van de literatuurstudie is meer kennis opgedaan over het concept van verkeersmanagement, verschillende verkeersinformatiesystemen aan de kant van de weg en in de auto. Teven is het (opvolg)gedrag van de automobilisten tegenover de gepresenteerde verkeersinformatie bestudeerd.

De twee hoofdcategorieën van de verkeersinformatiesystemen hebben verschillende soorten visuele lay-outs en doeleinden. De dynamische verkeersinformatie die gepresenteerd wordt door wegkantsystemen heeft als doel de doorstroming en de veiligheid van de automobilisten te bevorderen. De informatie wordt dus met een algemeen belang gepresenteerd. In-car systemen echter geven vooral gepersonaliseerde informatie. Deze informatie heeft vaak alleen een positief effect op de weggebruiker die het in-car systeem gebruikt.

Het gedrag van de weggebruikers naar aanleiding van de verkeersinformatie is verschillend voor elke situatie op de weg. De reactie van de weggebruiker tegenover de verkregen informatie hangt vaak af van de eigen vaardigheden en visie. Daarom bestaat de algemene weggebruiker niet.

Uit de literatuur studie bleek dat de meningen ten opzichte van de DRIP(s) nog steeds verdeelt zijn. De weggebruikers lezen de informatie wel maar volgen deze niet altijd op. Hier tegenover staat dan weer de gepersonaliseerde informatie van de in-car systemen, deze worden wel als positief ervaren, en meer opgevolgd. Echter, de in-car systemen kunnen ook leiden tot afleiding en mogelijke onveilige verkeerssituatie. Naast de presentatie van de informatie hangt het verkeers- en route afwijkende gedrag af van de verkeersomstandigheden, de oorzaak van de vertraging, de mogelijke alternatieve routes, het wegontwerp en de bekendheid van de weggebruikers met het desbetreffende traject.

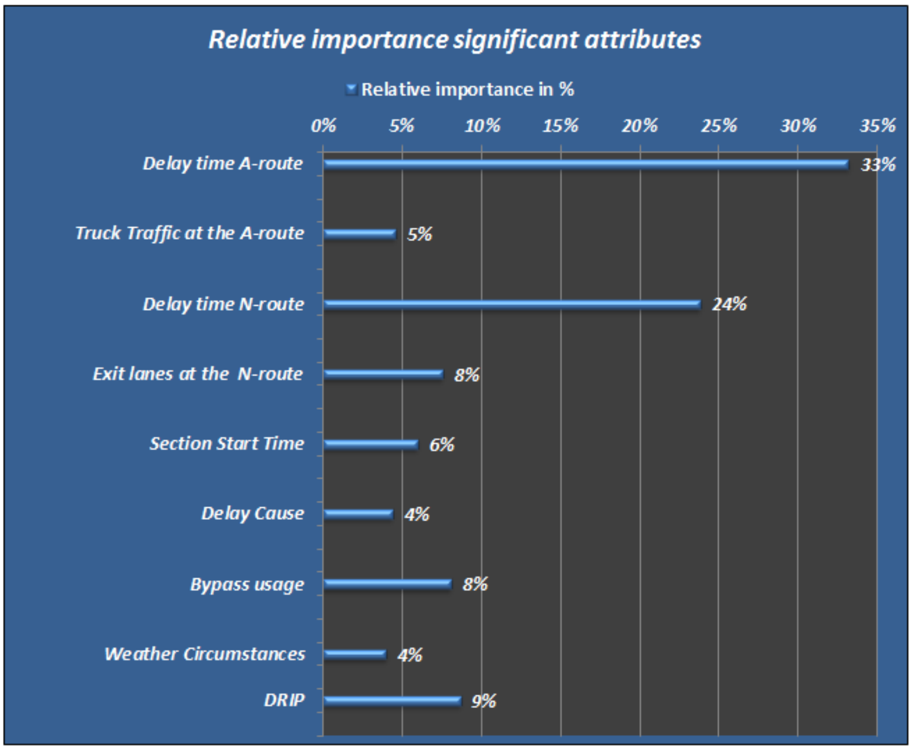
Doormiddel van de opgedane kennis tijdens de literatuurstudie is een Stated Preference (SP) experiment opgezet. Het SP experiment is opgezet om het routekeuzegedrag van de weggebruikers op ontvlechten snelwegen te achterhalen met gebruik van verschillende verkeersinformatie media. De visualisatie van de verschillende verkeersinformatie media bronnen is een belangrijk aspect binnen het SP experiment. Om een zo realistische mogelijk beeld te creëren moeten de verkeersinformatiesystemen gepresenteerd worden zoals de huidige systemen gebruikt worden en op de markt verkrijgbaar zijn. De systemen moet gepresenteerd worden in een bekende omgeving, daarom is ervoor gekozen om de situatie te beschrijven vanuit een in-car perspectief. Hierdoor krijgen de respondenten het gevoel daadwerkelijk de auto te besturen.

Alle attributen zijn, indien mogelijk, gepresenteerd door pictogrammen om de informatie belasting te verlagen en zo begrijpelijk mogelijk format te creëren. Tijdens het SP experiment heeft de respondent de mogelijkheid gekregen om tussen twee verschillende route opties te kiezen; de A-route en de N-route. De A-route is voor het doorgaande verkeer, en de N-route voor het lokale verkeer.

De gegevens van het SP experiment zijn verzameld met behulp van een online vragenlijst. Deze vragenlijst bestond uit drie verschillende onderdelen. Het eerste deel heeft betrekking tot het gebruik van de verkeerinformatiesystemen, het tweede deel bevat het keuze-experiment, en het derde deel bevat een aantal sociaal-demografische vragen.

Na de dataverzameling is de data geanalyseerd met behulp van het multinomial logit model (MNL). Het MNL model heeft doormiddel van de part-utility laten zien welke attributen of in andere woorden, kenmerken, invloed hebben op het routekeuzegedrag van de weggebruikers. Binnen het MNL model is er onderscheid gemaakt tussen de route gebonden kenmerken en context gerelateerde kenmerken. De routekeuze specifieke kenmerken waren voor beide route opties vertragingstijd. Voor de A-route tevens nog het percentage vrachtverkeer, en voor de N-route het aantal afritten. Deze twee kenmerken waren nog niet eerder onderzocht in een dergelijke situatie.

De weggebruikers maken verschillende keuzes gebaseerd op een hun persoonskenmerken zoals het geslacht, leeftijd en rijervaring. Uit het optimale MNL model bleek dat de weggebruikers met de verkregen verkeersinformatie tijdens het rijden op ontvlochten snelwegen een routekeuze maken die gebaseerd is op de extra vertragingstijd van de verschillende routes. En wanneer deze informatie gepresenteerd wordt door DRIP(s). Ook de eigen perceptie van de automobilisten speelt en rol bij het maken van routekeuzes. Rekening houdende met de route specifieke kenmerken, zoals het vrachtverkeer en de extra stress veroorzakende rijtaak die komt kijken bij het nemen van afritten op de N-route. Van de overige niet-route gebonden kenmerken baseren de weggebruikers vooral hun keuze op het tijdstip van de dag (spitsuur). En hoe vaak ze gebruik maken van een bepaald wegtraject, in andere woorden de bekendheid van het traject. Figuur 1 geeft het onderlinge relatieve belang van alle significante kenmerken aan.



Figuur 1 Relatief belang van de significante kenmerken

Een aanbeveling voor beleidsmakers en Rijkswaterstaat is dat het huidige DRIP systeem nog niet weggehaald of vervangen kan worden. Dit omdat deze nog steeds intensief gebruikt worden, zelfs in combinatie andere in-car verkeersinformatiesystemen. Verder onderzoek kan gedaan worden door andere specifieke in-car verkeersinformatie systemen in combinatie met de DRIP te onderzoek, zoals de smartphone apps.

ABSTRACT

With the increase of congestions on the highways and upcoming usage of in-car traffic information systems the older systems need to be reevaluated. These systems are there to provide traffic information and decrease traffic congestions. The DRIPs are mainly placed at unbundled roads, which consist of a regional road and local road. Separating the regional and local traffic streams increases the traffic flow and reduces the congestions. The DRIPS is not the only systems that provides traffic information while driving on unbundled road situations, there are several other means of receiving traffic information. These other means are the navigation systems, smartphone applications, and radio systems. The combination of these systems is called in-car systems. The current road-side systems (DRIPs) can be compared with the new evolving in-car traffic information systems. A stated preference experiment is used to collect data of road user’s route choice decisions at unbundled highways with use of different traffic information media. The collected data is analyzed using a multinomial logit model, which resulted in showing which attributes affect the route choice behavior. There was a difference made between route choice specific attributes and context related attributes. The route choice specific attributes truck traffic at the regional route and exit lanes at the local traffic route have never been researched before and gave new insights in the route choice behavior. Were a high level percentage of truck traffic showed an increase in preference towards a regional road and an increase of exit lanes a decrease in use of local roads. Travel delays times displayed by a DRIP and a DRIP being active had the most significant impact on route choice behavior.

LIST OF ABBREVIATIONS

AID	- Automatic Incident Detection
IIA	- assumption of independence form irrelevant alternative
ANWB	- Algemene Nederlandse Wielrijdersbond
ATIS	- Advanced Traveler Information Systems
DRIP(s)	- Dynamic Route Information Panels
FCD	- Floating Car Data
GRIP(s)	- Graphical Route Information Panels
ITS	- Intelligent Transportation System
IVHS	- Intelligent Vehicle Highway Systems
RP	- Revealed Preference
RWS	- Rijkswaterstaat
SBVV	- Strategisch Beraad Verkeersmanagement en Vervoersinformatie
SP	- Stated Preference
VID	- Verkeer Informatie Dienst
VMS	- Variable Message Signs

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1. INTRODUCTION

This chapter introduces the research design of the graduation thesis. The main reasoning for this thesis is based on the current traffic information systems which are used to spread the traffic load and control the traffic flow. Spreading the traffic load by traffic information systems will be described with the use of a few illustrations. This description is followed by an overview of the research done during this graduation thesis, starting with the problem explanation and definition followed by the research question and approach. Section 1.5 of this chapter provides a reading guide for the complete thesis.

1.1. Research motivation

In the current environment a lot of people are often in a hurry caused by a fully planned schedule. Travelling between appointments is done in various ways: one of them is travelling by car. Many car users also known as the (highway) road users are experiencing stress while travelling. The stress that is experienced while travelling by car is often based on delays that road users are experiencing. But also the presence of other road users and the high amount of traffic increase the stress level of the road users (Gatersleben & Uzzell, 2007).

Spreading the road users over different routes lowers the traffic load each of the routes. It also increases the travel speed and lowers the stress level of the road users. Division in to two roads, or in traffic terms called unbundling[2] the roads, is separating a single road into more individual roads with physical borders. This is a common occurrence at the road network in the Netherlands. It is basically done to stimulate the traffic flow and separate traffic into regional (transit) and local traffic flows. Unbundling is currently done at several road segments in the Netherlands; the A2 and the A12 near Utrecht, the A2 near 's-Hertogenbosch, bypass[3] A2 and N2 Eindhoven, the A4 near Leiden and the A15 near Rotterdam. To safeguard the transit traffic at the highways weaving[4] lanes and exit lanes are created to guide the local traffic. The unbundling of lanes create a system of main and parallel lanes. Figure 1 shows an example of main and parallel roads. A downside of using unbundling traffic flows is that road users have to choose the parallel runway in advance to get off at the right exit (Van Loon, Walhout, & Van Der Velden, 2015).

Figure 1 Main (regional) and Parallel (local) roads (Source: maps.google.nl)

[2] Dutch 'Ontvlechting' of the roads
[3] Dutch: Randweg Eindhoven
[4] Dutch: weefvlakken

Before choosing between the regional and local traffic lanes, several static and dynamic signs are shown to provide information of which road is connected to what area. An example of these signs and placements at the roadside is shown in Figure 2. In this context Variable Message Signs (VMS) are available. These signs provide additional information about the road conditions such as: travel time of different route alternatives, delay time, traffic congestion, and road accidents. The objectives of these signs are to lower traffic congestion, to assure safety, to decrease traffic accident rates, and to enlarge capacity of the road networks (Li, Cao, Zhao, & Xie, 2015). The VMS are best managed with programmed strategies to give high quality information and guidance to drivers in order to improve the capacity of a road network (Baofeng, Zhicai, Leleur, & Wenjing, 2005). The pre-programmed strategies assure the most optimal guidance for different situations.

Figure 2 Dynamic sign (VMS) and the (blue) static signs background left. (Source: RWS-beeldbank 2013)

There are two main categories of road unbundling, soft and hard unbundling. Soft unbundling gives the opportunity to keep switching between different road and road lanes. Whereas hard unbundling gives no opportunity to switch between the different roads until a next intersection point is reached. Currently, the soft unbundling of roads is presented by static signs. The VMS give extra information about the conditions for the hard unbundled roads. Figure 3 gives an example of a 'bermDRIP' which are often installed before road unbundling situations providing traffic related information. These kinds of DRIPs provide information as described before a certain intersection point. Every road connected towards an unbundled bypass has a DRIP system installed. These DRIPs are all located at different locations and distances before bifurcation of the other connected regional roads.

The ultimate goal of separating the roads is creating a fast traffic flow mainly for the passing through traffic. The capacity of the infrastructure of the highways increases by 5%-13% by creating separated roadlanes for local and regional traffic (Van Loon et al., 2015). A downside of the unbundling of these roads is the low flexibility of the capacity whiles the intensity of the traffic increases. For example, traffic on both roads cannot take advantage of spare capacity in the other lane when intensity is higher than capacity.

In the Netherlands an unbundled situation consist of a main and parallel road, which will be called a regional traffic road and local traffic road during the rest of this study. There are some cases where both unbundled lanes are for regional traffic, but were one road has additional exits lanes. The regional and local traffic roads consist out of a minimum of two lanes in both directions. In total this results in a minimum of eight road lanes. The unbundled roads are often located around city bypasses. This results into a positive traffic flow for the transit traffic around the cities. The total length of these situations are mostly between five to fifteen kilometers.

Figure 3 Example of a bermDRIP (Source: maps.google.nl)

Traffic management centers are playing an increasingly important role in improving the traffic flow, traffic safety, and in better utilization of the road capacity. Partly due to the use of route information panels and dynamic reversible lanes, road traffic managers can now ‘guide and control’ the traffic and in that way improve the traffic situation (Godthelp, 2012). However, there are more institutions and companies which have access or their own data consisting travel information and can provide personal traffic information directly to the road user, through for example a navigation system with real-time traffic information or through smartphone applications.

1.2. Problem definition

At the moment there are many different ways of guiding road users and controlling traffic flows. Guiding and controlling is done with the use of different smart traffic information systems. The traffic information systems are divided in a few categories, with the main categories road side information systems and in-car systems. In today’s world, it is important to provide traffic information successfully and control the behavior of the road users until certain extend. Road users’ behavior needs to be taken in consideration when designing such systems. There is already a lot of research done towards how information should be displayed on the VMS and which factors are influential on route deviation behavior due to information provided. But less research towards the VMS in combination with the upcoming new technologies which also provide traffic information. In the near future more new sensors, media, and information media will be merged into new information systems, both for the road users and for traffic managers (Godthelp, 2012). The information that is provided in-car with the use of applications on smartphones and navigation modules with live traffic updates give personalized travel information. Current roadside systems provide only general beneficial traffic information. The trend of personal traffic information will attract different parties and services to provide traffic information with the means of different in-car systems and mobile devices (Kroon, Martens, Brookhuis, & Hagenzieker, 2014)

Currently there is a lack of knowledge regarding the relation between DRIP and in-car distributed traffic information and the behavior of road users towards this information.

It is especially important for the government, in particular Rijkswaterstaat, to find out if the placed DRIPs are still used and influential for traffic guidance in combination with the upcoming new media. Applications on smartphones and other personal navigational systems are evolving at such a high speed that the time is there to evaluate which systems need to be improved and developed and which systems can be abandoned.

1.3. Research question

The question that is currently asked by Rijkswaterstaat is how the DRIPs influence the drivers' route choice behavior in unbundled road situations. Currently, there is not enough information available that provides insights into the way road users act and make decisions based on displayed information. The so-called follow-up behavior of the drivers is currently not being monitored by Rijkswaterstaat. It is known what the traffic streams are but not how specific shown DRIP messages influence the decisions made by the road users. That raises the question about the influence of the DRIPS as a traffic information medium. Knowledge on road users' behavior towards traffic information media is needed because even the most sophisticated traffic information systems can be unsuccessful if we are unable to understand the behavioral consequences. Aside from the messages shown by the different media the different context and road related attributes can influence the behavior of road users as well. This notice brings us to the main research question:

Which context and road related attributes influence the route choice behavior of car drivers at unbundled highways with the presence of different traffic information systems?

The main objective of the study is to find out which medium in what circumstances has the most effect on the car drivers' route choice behavior for unbundled highway situations. It is important that this information is handed over in an understandable format. Several researches have been carried out by Rijkswaterstaat on which traffic related information sources road users have to their disposal; how the format should be designed; how road users use these sources; and what is their level of satisfaction about these services. The main research question is very broad and needs to be divided into a few sub-questions which will result in the final answer for this research.

Sub-questions based on the main research questions are:

Which dynamic traffic information systems are currently in use by road mangers and users?

Which characteristics are most influential for road users in route adaptation behavior?

How do people act based on the traffic information streams?

Which and what effects do traffic information media have in different circumstances?

With this information, assumptions about the possible trends evolving in traffic information distribution and behavioral patterns of road users guidance can be made.

1.4. Research design

From reading extensive literature about presentation of traffic information and traffic behavior, it appeared that many of the researches were conducted using discrete choice experiments, real-time traffic observations, and data generated by simulation models. These methods have certain limitations and some of them will be discussed below. The methods can be separated into two different categories. The first category is based on by field observations; perceiving what is done by observing subjects and what choices are made. The second category is based on laboratory controlled experiments, creating different controlled circumstances and asking the respondent to make a decision. The advantage of a laboratory experiment is that all the attributes can be controlled and new not yet measureable attributes can be added in the situation.

Many of the researches already done focused on estimating only major effects of providing traffic information to road users, ignoring detailed effects from highway types, motorists' demographical characteristics, and traffic patterns (Sangyoup Kim, Jeong, Choi, & Tay, 2014). Real-time traffic observation is one way of doing research towards route choice behavior. This can be done by counting cars and evaluating which way the road users go when driving. Combining the route choice with a certain message displayed at the road signs gives additional information of the route choice made. A disadvantage is that no information is available about the drivers' characteristics and other in-car traffic information systems used. The effectiveness of the DRIPS can be measured with real-time traffic observation but with caution and bearing in mind that road users could have used other information media. It is not known explicitly if the route choice is directly based on the information given by the DRIP only.

Another type of observing traffic is with the used of GPS data in combination with DRIP log data. The data gathered by GPS gives a lot of information when combining it with the DRIP log data. The GPS data or often called Floating Car Data (FCD) can be obtained from different sources such as smartphones and navigation systems. The advantage is that the data is often available in large amounts, in the so called 'Big Data' files. The traffic streams can be visualized with the use of this data in combination with map matching. Combining these visualized streams with DRIP log data gives a clear understanding about when road users change direction from one suggested route to another. With the information given by the DRIPs the effectiveness can be measured. There is however still no information avaiblable about the driver characteristics and combination of other in-car traffic information systems.

Creating a laboratorial set-up with a fictive car driving on a highway with traffic information presented by different sources can provide information about the impacts of providing drivers with real-time traffic information. The laboratorial results can support the notion of road users decisions made to divert to alternate routes including in-car systems in the simulation DRIPS (Dia & Panwai, 2007). This method is however not chosen for this research because of the timeframe of this graduation project. However, the information gathered with this method contains all the information that is needed for this study. Which is all the behavior towards the different traffic information systems, and the respondents characteristics. However reaching many respondents and creating a traffic management laboratory set-up is too extensive for the knowledge of a graduate student.

Data can also be gathered with the use of relatively low number of respondents. This can be done by making real observations while driving along with the respondents. Driving along with the respondent recording decisions made while driving on the highway in different situations and different route information displays. This way it is possible to get direct input from the respondents while they are driving. The findings however are often lacking the ability to generalize to wider societies, being biased towards age, gender, etc. (Kawulich, 2005). A limitation of this way of gathering data, aside from being time and money consuming, is that not all circumstances will be covered during the observations. It is needed to assume too much if not all possible variables that can be taken into account. For instance, if the navigation system does not provide an alternative route because there is no delay at that moment in time or when the DRIP is only providing regular travel times and no delay times.

Gathering data with questionnaires can offer insights into car drivers' way of perceiving information and their reaction towards this information. However, the respondent who fills in the questionnaire can interpret the question differently than it is intended to be and therefor answers get a different meaning. Questionnaires with stated preference questions however can provide carefully created scenarios with a lot of controlled attributes to gather the data that is needed to evaluate route choice decisions. These scenarios can be designed to contain the whole context that is needed and still present a real-life situation.

Additionally, the questionnaire can be used to gather data of the drivers' characteristics and experiences towards traffic information systems.

Table 1 gives an overview of the pros and cons of the evaluated methods in gathering the needed data for this study.

Table 1 Data gathering method selecting

	Real-time traffic observations	*Driving along with respondents*	*GPS (big data usage)*	*Laboratorial setup*	*Stated preference*
Gather choice data	✓	✓	✓	✓	✓
Low costs	✓		✓		✓
Quick gathering method			✓		✓
Respondent characteristics		✓		✓	✓
Add new attributes				✓	✓
Control over attributes and attribute levels				✓	✓

With the use of table 1 one gathering method is selected, the so called Stated Preference (SP) approach. SP experiments are often used in transportation studies for estimating and forecasting behavior of travelers, road authorities etc. (Rose & Bliemer, 2013). SP originally comes from the economic market where often marketing research has to be done towards new products. However, SP is increasingly more used for transportation research (Hensher, 1994). Within a SP research the respondent can be asked either to rate, to rank or to choose a hypothetical option. The SP scenarios applied in this thesis consist of multiple options available and the respondents are then asked to choose one alternative in the given situation. It is important to create different controlled scenarios for the highway users which consist of visualizations of a particular situation in time on the highway. The scenarios will not be based on a specific case and therefore the scenarios will be generic as much as possible but with the characteristics of an A and N road as main labelled alternatives. Socio-demographic information is also needed for this research and can be included in some general questions.

Another advantage of using SP experiments instead of other route-choice simulators is that the scenarios can be designed to relate them to the driver's actual travel journeys (Chatterjee, Hounsell, Firmin, & Bonsall, 2002). SP does not only has advantages but also has a few shortcomings. The first one is that the road users may not act the same towards the given scenarios compared to real-world situations. The scenarios created are forced to have certain boundaries, because not every variable can be taken into consideration. This can have a significant effect on the decision made by the respondent and it is not known for sure if they will act this way in real life (Li et al., 2015). This can be checked by Revealed Preference (RP) approach. However, this is too expensive and time consuming for this graduation study and can only reach results that are limited to the specific messages displayed during the survey period. RP data is often gathered by direct observations or by self-reported data by the respondents. Another disadvantage of SP is that the scenarios need to be designed carefully which is very challenging and can be relatively time consuming. Mistakes made while designing the scenarios can result in skewed results.

1.5. Reading Guide

This section explains briefly the built-up of the graduation thesis as graphically displayed in figure 4. The problem definition and research aims and question are discussed in the previous sections. Chapter three starts with a brief description of the literature study towards traffic guidance in general. This chapter is followed by chapter 4 describing human behavior in traffic. After the two chapters focusing on the literature study, the set-up of the stated choice experiment is discussed including the data collection, data analyses, and results. Finally, the thesis will end with a conclusion also containing the discussion.

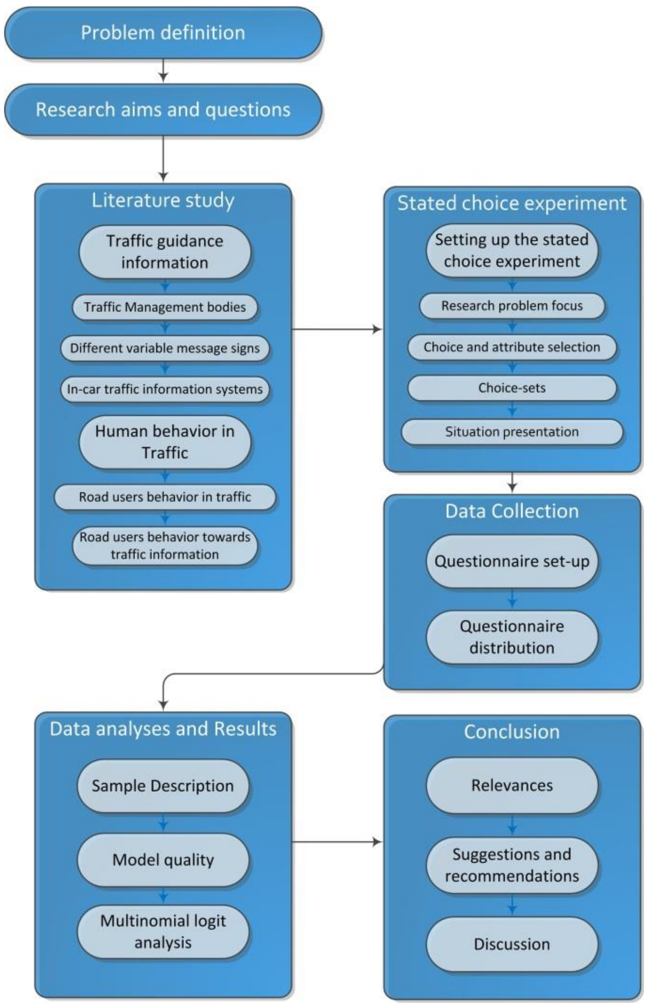


Figure 4 Thesis design and reading guide

2. GLOSSARY

The glossary contains general explanation of a few definitions and context. This is done to create a more clear view on the subjects that will be discussed in the following chapters.

One of the most frequently used terms is ***road*** and ***road lanes***. A road can consist out of different lanes, which are called road lanes. The situation description often uses these words together. The two main roads used as choice alternatives are the ***regional roads*** and the ***local roads***. The regional roads are the roads meant for traffic that is on transit, or in other words passing by. The regional roads are most often roads with a higher speed limit than the local roads. In some cases the local road has the same conditions as the regional roads but with additional exit lanes. For instance they are both an A-road. The local roads in this research are roads that are situated parallel of a regional road but with additional exit lanes to leave the ***bypass of the city***. The bypass of the city is the combination of both the regional and local roads around cities.

The ***Variable Message Sign (VMS)*** is a term used very often and is widely recognized. It indicates all the signs that are variable and can display different kind of digital information, which can be adjusted at any moment in time. In the Netherlands there is an own abbreviation for VMS which is ***DRIP(s)***. DRIP(s) stand for dynamic route information panel(s), or in Dutch 'Dynamisch route informatie paneel.' During the research the term DRIP is used to indicate a form of VMS.

From the different navigation systems the ***navigation system with live traffic information*** is used in the stated preference experiment. Navigation systems with live traffic information provide live feats of specific traffic incidents, including accidents, roadworks, and road congestions. The navigation systems then provide information that includes the delay time and other faster alternative routes.

A regular used term in combination with live traffic information is ***Floating Car Data (FCD)***. FCD is data that is gathered by the road users. These road users have certain systems in their cars that transmit information into the air. This signal is created by several means; the most important ones are the smartphones and navigation systems. The FCD is then used to determine the speed of the current traffic, the congestions, and much more. Often traffic management bodies have the opportunity to combine this data with information systems at the road side, such as cameras, traffic measurement loops and Bluetooth sensors (Wilmink, Malone, Soekroella, & Schuurman, 2014).

During the stated preference experiment ***situations*** are designed. Situations are specific circumstances that a road user can face in reality. The situation have certain ***situation based aspects*** these aspects describe the situation more carefully with the use of different ***attributes***. Attributes are explanatory aspects of the situation description. Which are carefully selected during the literature study following in chapter 3 and chapter 4.

Attributes consist out of different ***attribute levels***. These levels indicate a certain amount, value, aspect, or context. The attributes are al described in section 5.1.

3. TRAFFIC GUIDANCE INFORMATION

This chapter provides some general description of traffic information management. It also contains information about the use of dynamic and fixed information systems located alongside the Dutch highways and in-car media that can be used by road users in receiving traffic information.

3.1 Traffic management bodies

Traffic guidance service is real-time traffic information or guidance setup for and provided to road users. The traffic information consists of actual traffic conditions, delays caused by congestions, delays caused by accidents, availability of parking facilities, and presence of roadworks. Governmental bodies and market parties can provide information and guide all road users on the Dutch highways with a certain guideline in presenting the traffic related information.

3.1.1 Governmental traffic information guidance

The governmental guidance in the Netherlands is done with the use of operational traffic management which is controlled in so-called traffic management centers. The governmental body which is responsible for the national roads is RWS. There are in total six traffic control centers in the Netherlands, one national control center and five regional traffic control centers. The five regional traffic control centers are located in the Netherlands from north until south in Velsen, Rhoon, Utrecht, Wolfheze and Helmond. There is one umbrella organization from RWS in Den Haag which focusses on process improvement of the regional centers. The goal of each control centers is to control a part of the highway road network in the Netherlands. The traffic guidance in these centers aims to stimulate road user's behavior by displaying traffic information that will support the traffic flows, safety, and keeping the roads as sustainable as possible. Other main tasks of the traffic management centers consist of (Godthelp, 2012):

- Informing and warning;
- Guiding and controlling;
- Managing incidents;
- Harmonizing and supervising roadworks;
- Monitoring and controlling objects.

Gathering traffic information need to be done before the traffic information can be presented. The gathering of the information is done by the traffic control centers 24 hours per day and seven days per week. The gathered information consists of FCD, camera data, traffic loop data, and more. All this so called 'big data' is stored at the national databank of road traffic data. It is RWS' job to gather, distribute and provide process related information. Other service providers such as the VID and the ANWB present the regular traffic information which will be beneficial for all road users. The information that is purely

descriptive, is not always mandatory to follow and can be ignored by the road users if they decide to do so. An example of mandatory information is a closed road lane due to roadworks or an accident. Non-mandatory information concerns the presented delays with route deviation suggestions due to traffic congestions.
RWS uses more systems alongside the roadside systems to distribute their traffic information, such as internet sites, teletext pages, SMS-services and a telephone information number. The information provided with these systems consists of travel time, traffic jams, delay time, road status information, and travel deviation routes. With the use of this information the road users get an overview of the road circumstances and conditions ahead. The information takes away the uncertainty that may occur during the journey. These uncertainties can be the difference in travel times at different parts of the day and travelling in peak-hours which can increase the travel time.

3.1.2 Traffic information spread by other parties

Traffic information provided by third parties contains often unique services but not always for a free. This information can consist of personal travel information suggestions, predictive traffic jam information, and so on. At the moment popular smartphone specific applications are Google Maps, INRIX, Flitsmeister, Apple Maps, and TomTom navigational app. These applications are not the only apps provided by third party information distributors. It also includes GPS navigation based systems providing personal route information services. The parties spreading the traffic information with the use of smartphone applications and navigation system often use their own FCD, gathered by the users of the products.

Also other systems like the 'radio data system traffic message channel' (RDS-TMC) receivers provide traffic information. Information spread by the radio and also television, is often done by the Dutch Traffic Information Service, Verkeers Informatie Dienst (VID) which is a Dutch traffic service information provider. With the use of combining information from different sources such as fixed cameras, traffic loops, and more. The combined information is provided to road users with the use of radio, television, internet, navigation, telephone and text services.

The road user has the possibility to travel fast, comfortable and safe with the use of these services. A big advantage over a fixed road system is that the information of these services can be received in-car everywhere at any time. The in-car systems will be more thoroughly discussed in chapter 3.3.

3.1.3 Presentation of the traffic information

All the different parties that gather the traffic data need to present these data to the road user in an understandable format. A Dutch meeting which was called the Strategisch Beraad Verkeer en Vervoer (SBVV) representing some market parties and some governmental bodies, made a document describing how information services around roadworks, route information and navigational systems should be distributed. This document is important because the document describes how to create a more uniformed design when presenting traffic information, especially now, with the rise of GPS navigational systems, smartphone applications, and other in-car technologies. More detailed information about the agreements that are made can be found in the so called 'Pact of Sint Michielsgestel' which is a public document[5].

The different media that are used to spread the traffic information consist either out of personal and general traffic information. The currently active road side systems with general traffic information are likely becoming more obsolete with the evolution of the new in-car services. The advantage of these personal services is that the traffic information will be more direct, person-bounded, and timed. This means that the traffic information will be more user-specific and will be presented more directly to benefit one road user. Personal route information is followed more often as stated by Taale & Schuurman (2015). Approximately 14% of the road users in the Netherlands change their route when information is received on a personal GPS-system, in contrary to general traffic information which is 6%. The behavior of road users towards the information will be more thoroughly discussed in chapter 4.

With all the possibilities and different media in spreading traffic information, the primary task which is driving should not get pushed to the second place. Therefore, the messages shown at road signs, navigations systems, smartphone applications, and through radio messages should be kept as short as possible and low-demanding to prevent an information overload (Kroon et al., 2014). These short succinct messages can be interpreted in multiply ways, and can lead to confusion by some road users. This can result into unsafe and unwanted driving behavior. Kroon (2014) therefore said that these messages should be clear and unambiguous to secure traffic safety and the messages should not be displayed in different colors. Because in the Netherlands, about 1 out of every 12 men and 1 out of every 200 women has red-green color blindness. The information needs to be spread efficiently. The following factors are important while spreading the information efficiently: timing, location, and traffic circumstances. The timing and location of the presentation of the message need to be taken in consideration in relationship to environmental circumstances such as sharp curves and road deviations. Presenting the message way ahead at high traffic density roads sections is important to guide the traffic safely.

3.2 Different Variable Message Signs at the roadside

Variable Message Signs (VMS) are important components in providing traffic information towards road users with the use of the Intelligent Transportation System (ITS). The dynamic VMS signs are managed from the traffic control centers all over the country. The sign itself usually consists of a large set of LED lights aligned in a grid forming the information and symbols (Nienhüser, Gumpp, Zöllner, & Dillmann, 2008). These signs are used to control and guide the traffic flow on most highways. The information displayed on the VMS consists of traffic information about the cause of congestion, delay time, maximum speed, and other

[5] https://www.yumpu.com/nl/document/view/8309955/het-pact-van-sint-michielsgestel-connekt is a direct link to the file, which is in Dutch.

viable information such as possible route deviation suggestions for the road users. The goal of the information is to help drivers with their decision making and provide a safe journey with an lower accident rate, less traffic congestion, assure safety, and enlarging the capacity of the road network (Baofeng et al., 2005).

Previous research from Wardman, Bonsall, & Shires (1997), K. Chatterjee et al. (2002) and Khattak, Schofer, & Koppelman (1993) has shown that the delay time shown on VMS has more significant effect than showing the actual travel time, more specifically delays with a specific cause, provide more route diversion. Aside from diverting road users to other routes, the presentation of correct[6] and location based information about congestions can benefit the traffic flow as well. The location information presentation, delay length, and detailed information of the traffic conditions in a case of an incident and to organize actions to clear the incident area are important. Presenting the information with certain attributes is not the only way of distributing the information. The actual placements of the signs are also important to control the traffic flow and spread the traffic volume over the full capacity of the roads. Offering the road user enough time to read, interpreted, and make a decision based on the information provided by the signs. The VMS are often placed in the vicinity of busy intersections, which are important key points to distribute traffic information to the road users and provide information for route alternatives and travel information. Providing the information is done with the use of three main VMS in the Netherlands, being DRIPs, GRIPs and Matrix signs, discussed in the next paragraphs. First, a short paragraph will be devoted towards static signs that guide the traffic on highways in the Netherlands.

3.2.1 Static road information panels

Static road information panels are used to indicate routes, road, road lanes, locations, and much more. There are still some differences in guidance for unbundled road situation in the Netherlands. The signage of static route signs needs to be uniform and clear for the road users to understand. The information needs to be presented at ways of advance, especially of busy traffic intersection and complex weaving areas. The static route signs are the signs that provide the guidance towards the different intersections, roads, and road lanes. Without the static route signs the road users will not be able to find the suggested routes by the DRIPs. Figure 5 shows a standard static sign. One needs to know that these signs are still important for the route guidance and route selection; the other dynamic systems are discussed more thoroughly.

Figure 5 Static road signs in the Netherlands

[6] If this information is different for the actual situation the road user may not trust the given information the next time.

3.2.2 Dynamic route information panels (DRIP)

One of the most common used VMS in the Netherlands concerns DRIPs. DRIP signs are placed at tactical decisions points, which are mostly close to highway intersection points, these points provide the best opportunity to present road conditions ahead and provide several alternative routes available. A regelation is available for the presentation of information by the DRIP. DRIPs are used to display planned road constructions, special events, and other road traffic management information for the road user. The road traffic management information consists of travel times, delays, detours and delay causes on the particular road segment. In the Netherlands, the DRIPs mostly show fixed travel times over the particular segment, which is often from one motorway junction to another. If there are any delays, the DRIP will report these including the reason of the delay. After peak-hours, the DRIPs are used to provide information containing standard fixed travel information or slogans from different traffic campaigns. The so-called road side VMS ('bermDRIPs' in Dutch) are dynamic signs placed at the side of the road which show traffic information and constant travel times including the possible delay on that specific local segments. The last mentioning worthy DRIP system that is also available in a small amount concerns the DRIP+ that is a road wide dynamic sign, which can be programmed to display both textual and graphical information for each specific road lane. Figure 6 gives a visual overview of all the DRIPs.

Figure 6 DRIP | bermDRIP | DRIP+ (Source: RWSbeeldbank | swarco.com)

The general layout of the DRIP consists of the intersection with the normal travel time, including the possible delay, and the delay reason with a displayed icon. Several studies have been done towards the display of information. The use of symbols instead of characters was preferred by the respondents. These symbols should associate with current already know traffic signs and symbols used by in-car systems (Rijkswaterstaat - Adviesdienst Verkeer en Vervoer, 2007). Figure 7 shows a general layout picture of the most commonly used DRIP layout with icons, these are also used in the further research of this thesis.

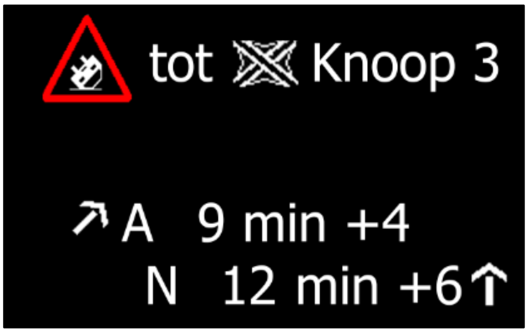


Figure 7 DRIP Layout

3.2.3 *Graphical route information panel (GRIP)*

GRIP which is short for Graphical Route Information Panel, is basically the same as a DRIP but is also displays a simplified graphical image of the highway junctions and road segment occupation. The delays of the road segments are displayed with different colors, travel time or textual explanation of the delay. The advantage of the GRIP system is that different route are more sophisticated and gives a quick overview of the exact delay location and possible options are visualized. The road users have the feeling that they can adjust their route if the two visualized routes come back together. This results in more road users taking the suggested route according to Van de Pas, Bever, & Lenting (2012). **Error! Reference source ot found.** displays a GRIP at the Dutch highway, the red road segment indicates a delay.

Figure 8 GRIP, displaying a simplified image of the road network. (Source: Rijkswaterstaat, 2013)

3.2.4 *Matrix signs*

Matrix signs are placed in the vicinity of busy highways sections above each lane. It assures that traffic can be controlled with the use of dynamic speed limits as well as spreading the capacity by opening or closing extra driving lanes. Figure 9 displays four matrix signs beneath static traffic signs. Most matrix signs work in cooperation with measurement loops ('meetlussen' in Dutch). These loops provide information about the speed driven at the current road section. The matrix signs display an appropriate speed limitation set between the boundaries of an algorithm. The adjusted speed limit is displayed to assure safety while riding towards a traffic jam (in Dutch this is called 'filestaartdetectie', (Soekroella, 2014)). The presented speed limits were recommended speed limits but it was changed later on. Nowadays the displayed speed limits at matrix signs are mandatory according to the law. Closing a road lane with the use of a matrix sign (displaying a red cross) can have several reasons. The road lane is closed because of roadworks or an accident. During rush hours the shoulder lane can be used as indicated by a matrix sign. The shoulder lanes need to be controlled carefully by the control centers because when a car breaks down the shoulder lane need to be closed immediately.

Figure 9 Matrix signs displaying a temporary mandatory speed. (Source: beeldbank RWS)

3.3 In-car traffic information systems

There are more systems that provide traffic information to road users, such as the in-car traffic information systems mentioned in previous paragraphs. The traffic information systems that are discussed in this section are three in-car systems: radio traffic information systems, GPS navigation systems and smartphone applications. The radio is one of the oldest medium for receiving in-car traffic information. Currently, the built-in car navigation systems with live update and the smartphone application are booming systems in providing personal traffic information. The major difference between the radio and the newer traffic information systems is the way of presenting the traffic information. Whereas radio provides more general traffic information and the other in-car systems provide personalized information.

3.3.1 Radio traffic information

The radio is one of the oldest in-car systems that provide traffic information to road users. Several built in-car radios have the function 'traffic announcements.' This function automatically switches to the radio station that provides traffic information. The information mainly consists of on route congestions, travel times, and delays both in kilometers and minutes. It also provides information of possible alternative routes due to road constructions and incidents. The given information tells at which road number and which section of the road the delays are. This information is given through an update by the radio stations every half hour. The provided information is not as up to date as the newer in-car systems due to the 30 minute timeframe between each update. However, if there are emergency messages and the urge is high such as in the context of a ghost driver or an extreme accident, the radio station will broadcast the message immediately. The information spread by the different radio stations to the road users is often provided by the ANWB and/or the VID. More recently, the information is also given with the use of data gained by application companies, such as Flitsmeister and ANWB app. Aside from providing traffic conditions the radio also provides speed controls. These speed controls are often provided by people who call a radio station or more recently by the booming smartphone app Flitsmeister.

3.3.2 GPS navigation system

There are several navigation systems available on the market as displayed in Figure 10. From left to right: simple interface build-in navigation, advanced build-in navigation system, loose navigation system, and navigation application for smartphone and tablets, which will be discussed in the next paragraph 3.3.3. In the Netherlands, 91% of the car users have a navigation systems in their household, were 67% of them are nomadic systems, 27% advanced built in car systems and 45% use an navigational application. This number exceeds 100% due to the fact that several household own more than one system. The system that is preferred and used for route guidance most often is the built-in car navigational system (Schaap, Jorritsma, Berveling, & Bakker, 2015).

The advantages of navigation systems are that these systems provide updated traffic information by data received from the manufacturer of the system used. Often this data is gathered by FCD. Updating the traffic information regularly is important because road conditions change continuously during the day[7]. However, only GPS systems with live-traffic information provide continuously updated information. The live-traffic information shows congestions, incidents, alternative routes which are more suited for the current road conditions and points of interests. Often these extra services are provided by an extra subscription.

Figure 10 Different navigational systems. source: (Schaap et al., 2015)

Aside from the regular traffic information, the navigational systems also provide speed limits, applied traffic rules and show locations of fixed speed controls. The navigation systems can also provide driving suggestions and expected risks ahead. These suggestions and risks consist of road lane suggestion, switching highways, indicating dangerous weather conditions, dangerous road situations, closed road lanes, and even when approaching a school.

The big difference compared to traffic information provided by the radio is that the information presented by the navigation systems is personalized for each individual road

[7] Change is conditions are for instance, new congestions, detours etc.

user, location based, and is updated more frequently. Previous research has indicated that with the use of navigation systems the destination is reached more quickly, with a shorter travel distance and when driving to a unknown area destination it gave a positive effect on traffic safety (van Rooijen, Vonk, Hogema H, & Feenstra, 2008). TomTom claimed that when 10% of all drivers use there so-called HD Traffic system the effect of the average travel time would decrease for all road users by 5% (TomTom, 2010).

3.3.3 Smartphone applications

The available applications (apps) on current smartphones are enormous and still developing rapidly. The advantage of smartphone apps is that they are customizable for each individual user. The app only shows information that covers the user's needs. One of these features is the possibility to provide personal route information. The route information is location based and it also provides points of interests and other facilities that are available in the near surroundings if wanted. The data and information provided by most smartphone applications is done with the use of FCD, this data gets a continuous feed of updates. A few big companies have major data files available to provide optimal guidance and information streams towards their app users. The data is generated by the users of the apps. The generated data is translated towards a more understandable for the apps users.

Current popular apps in the Netherlands are Google maps, standard map application provided by the manufacturer smartphone software, TomTom-app, ANWB-app, Flitsmeister, Sygic, Here Drive, Routeradar, VID, vanAnaarBeter-app, Waze, Facebook, Twitter, and Nu.nl (Rijkswaterstaat, 2015). Google Maps is by far the most popular used app on the smartphone (62% of the Dutch road users use it). Followed by standard map apps provided by the smartphone, ANWB-app, AnaarBeter-app, TomTom and Flitsmeister (Schaap et al., 2015) (Rijkswaterstaat, 2015). All these apps have different layouts and ways of presenting the information towards the road-user. The different visualizations make it hard to generalize one specific app layout; a few screenshots of the current popular apps are given in Figure 11.

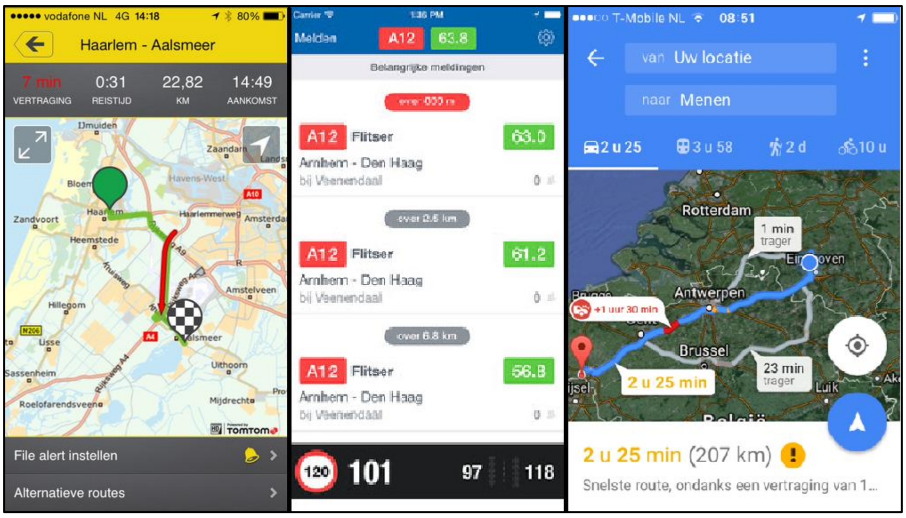


Figure 11 Popular smartphone apps, ANWB app - Flitsmeister app - Google Maps app

3.4 Conclusion

Which dynamic traffic information systems are currently in use by road mangers and users?

There are two different categories of traffic information systems; the roadside systems and the in-car systems. The roadside systems cover both the static and dynamic signs. The current used dynamic traffic information systems are VMS systems and in-car systems. The main difference between these systems is the way of providing the information, whereas the dynamic road-side system provides general information beneficial for the traffic safety and guidance of all road users. The in-car systems present road users with personalized information which is beneficial for each individual road user. The presentation of the road-side information is done by standard layouts designed by the road authorities, often in an unambiguous and short format. In-car systems are freer in presenting the information. This can be done in several different layout formats. For the in-car GPS systems and applications the road user can adjust the wanted information towards their preferences and needs. The provided information with the newer in-car systems gives the road users the opportunity to choose routes and alternative which benefit their own goals.

4. HUMAN BEHAVIOR IN TRAFFIC

This chapter presents some details of consists of behavioral patterns of human beings in traffic and towards traffic information. The literature study is done to create a clearer overview on how people react towards traffic information and guidance in earlier studies.

4.1 Human habitual behavior patterns in traffic

Road users have certain behavioral patterns. A brief literature study towards this subject resulted in a few perspectives on how the road users experience traffic and traffic information provided to them. One of these perspectives is that road users often cannot absorb all the information that is presented to them. This is valid if the road user is not familiar with the surroundings and the area when travelling. It can be said that the main focus for the traffic information is to show information that is applicable and does not confuse the road user. Human beings in general react differently to the prescribed information, and sometimes do not even act to the information or suggestions given. Moreover, human being are emotional decision makers, there can be considerable individual difference in reaction to particular information (Godthelp, 2012).

Not acting accordingly to the presented information has to do with habitual behavior and only accepting measurements which are useful to the drivers own opinion (Rijkswaterstaat, 2008). Pre-established expectations of a certain infrastructure area often overrule the fact of how the road segment is actually designed, marked, and calculated. (Rijkswaterstaat, 2008). People often do not know what is good for them, in assessing risks in traffic, and making inappropriate decisions. Most road users pursue their own goals, which are not always safe for the surrounding road users and can also be different from the goals road authorities have set. Individual travel patterns indicate that despite the diversity of the different travel histories of an individual, humans tend to follow simple reproducible patterns (González, Hidalgo, & Barabási, 2008). Therefore, the travel behavior is predictable or as said before, habitual. On the matter of this subject Godthelp (2012) showed that humans are emotional decision-makers. With the result that road users make decisions based on personal characteristics, experiences and/or habits. Route guidance systems are designed to provide road information which improves the road users' knowledge of the network. Bearing this in mind, the systems do promote aspects of habitual learning. Road users often follow the guidance provided by static signs. However, the behavioral pattern towards the static signs is hard to change even if the static signs change over time. This habitual response to guidance is impervious to changed circumstances, including improvements in guidance information (Bonsall & Joint, 1991).

Focusing more on commuters who often take the same route and are hard headed in changing to alternative routes. This has to do with the fact that commuters have tight schedules or often do not know any alternative routes or decided that their route is the most convenient one. These commuters do not want to deviate from their planned route because of their tight schedule and uncertainties of the alternative routes, therefor they act on a habitual basis. Research has shown that drivers prefer certain routes. Gan, Bai, & Wei (2013) found, with the use of a SP experiment, that commuter's primary route choice is the regional (transit) route. The commuter road users however deviate from their route if real-time traffic information is provided at the beginning of the journey. This information needs to contain additional routes which lowers the trip travel times (Jou, Hensher, & Chen, 2007). Knowing the alternative route beforehand can provide assurance and allows the driver to feel more confident in diverging from their original route. It is however known that usually only alert travelers actively use and search for travel information. While the non-alert travelers with established travel habits are less likely to actively search for traffic information (Godthelp, 2012). As mentioned earlier, the traffic information that is presented to the road user on a personalized basis is followed more often. The personalized information results in a greater comfort and less uncertainty for non-active travelers and has the chance to break down the established habitual behavior (Godthelp, 2012).

4.2 Road users' behavior towards traffic information

Road users are free to make decisions and act freely towards gained traffic information in certain situations. However not all the information presented is free to interpret. The newer systems often need to be evaluated and tested to gain insight into how road users act towards the presented information. There needs to be an understanding on how road user react towards mandatory and non-mandatory information and make driving decisions based on that information.

What all road users have in common is that they make decisions that will benefit their personal outcome the most. Soekroella (2014) found that road users take personal beneficial decision based on traffic information gained. These decisions have in common that they all have a positive effect on the travel time. The travel time saving decisions are, taking route alternatives, different travel start times, change of transport mode, or even cancelling the trip if the possible effects and/or expectations are too bad. These beneficial decisions are all done on different moments in time, more specifically at different moments of the trip: pre-trip, on-trip or after the trip.

Pre-trip

Pre-trip information is information that is gathered before the start of the trip. Pre-trip information can be gathered using different kind of sources. The main sources were this information can be gathered are newspapers, radio, television, teletext, internet, traffic cams, and smartphone apps. Information presented in newspapers are often preannounced roadworks and detour routes. This information is less up-to-date compared to the other systems (Soekroella, 2014). Television sometimes gives traffic information during news presentations, but more often the teletext on the television is used for this information. Internet is one of the diverse sources to gather traffic information. This is because of the unlimited information that is presented on different websites from the government or other organizations. Internet traffic information is not only textual but provides different maps which display traffic congestions. Traffic cams are accessed through the internet and are not all open for public use. Sometimes the cameras are available to the road users, often with roadworks (Soekroella, 2014). The pre-trip information helps the road users to decide if the travel should even occur, or detours routes need to be planned. The pre-trip gained information often decides when and how the road user will travel. The pre-trip information should not be limited towards only highway information but also include public transport. This way the traveler can decide on its own which transport mode to choose (van de Pas et al., 2012).

On-trip

On-trip information is information that is gained while performing the journey. This information is presented using information sources as discussed in the previous chapter. Additional on-trip information sources are the mobile traffic signs, both static and dynamic. The behavior towards the in-car and roadside information will thoroughly be discussed in the next paragraphs. In general the road users are positive towards the on-trip traffic information. The follow up behavior of this information is not always the same for every road user. Li et al. (2015) found that based on gender women tend to be more reluctant to be influenced by on-trip information compared to men. Waerden, Timmermans, & Bockemuhl (2015) did research towards the influence or commercial offers received during the car trip. These messages provided through on in-car systems were effective enough for road users to divert from their route. It is suggested by van de Pas et al. (2012) that on-trip information should be displayed as an advice or suggestion. This way the brains can interpreted and decide the fastest on the information gained, in the often relative short decision periods.

Post-trip

Post-trip information is gained after the trip. This information is often gained to gather new knowledge for the traveler. This knowledge has influence on the future trips (Rijkswaterstaat, 2015). The knowledge from other trips has influence on the future trips when travelling on the same route. When on-trip information can be ignored by the familiar travelers and decide to take their own route not in line with the advice given (Bogers, 2009).

Road users tend to interpret the gained information in their own way. The effects of the decisions made by the road users often depend on the circumstances. Like the awareness of the surroundings, the reason of the congestion, the possible route alternative, and the predictability of the situation (Goede, Faber, Boertjes, Vonk, & Hof, 2010). If the presented information has no useful background information, the road users tend to drop the information and pursue their own goals. The pursued goals often have no positive effect on the network conditions (Bogers, 2009). An example of this is that there is a traffic jam announced with no background information or the reason of the delay. Then the drivers on that segment think that it is a regular traffic congestion, and they are deviating from the route by 10 to 40% (Van de Pas et al., 2012). These are raw numbers since other researches pointed out that obeying the travel information is often based on the travel purpose of the person. For instance, commuters deviate from their route around 47% of the time (Gommers & Blokland, 2004). Khattak et al. (1993) found that these commuters often return back to their original route when possible. This increases when the trip length gets longer. Commuters deviate with high percentages from the original route when the beneficial boundary is high enough. The commuters want to return to their original route when possible, because of their habitual behavior discussed in section 4.1.

During this research the focus lies at 'on-trip' travel information. This on-trip information will be presented by DRIPs and in-car traffic information systems for unbundled highway situations.

Aside from the available route information and personal beneficial effects for the road user, the skills and socio-demographic aspects of the road users themselves are also important, stated by several researches (Li et al., 2015), (Gan et al., 2013), (Dia & Panwai, 2007). Driving experience (in years) is one of the attributes that can be associated with driving skills in particular. Gan et al. (2013) found that the driving experience of the road users has effect on how road users act towards road traffic information. Often people with longer driving experience are more stimulated to follow traffic information that is presented. This research was however done in Shanghai. For the western countries the outcome could be different. This could be different due to the fact of social behavior and cultural habits.
The socio-demographic aspects of the road users such as age, gender, educational level, yearly income, and driving style have an effect on behavior towards traffic information with as main effect route deviation. Road users tend to base their decision on other users, resulting in copying the behavior and acting the same as their fellow road users. Now it is known that all road users react differently towards road information one needs to know how people react to VMS and in-car traffic information. This matter is discussed in the following paragraphs.

4.2.1 Behavior towards Variable Message Signs

Traffic Information presented on VMS is done with a certain layout as discussed previously in chapter 3. The presentation of this information has certain effects on the road users. The important effects on the drivers and their behavior towards it are evaluated in this paragraph. The description starts with the attributes that are influential towards the road user's behavior. The VMS discussed here are comparable with the DRIPs and berm Drips in the Netherlands.

Several researches ((Wardman et al., 1997), (Soekroella, 2014), (Kiron Chatterjee & Mcdonald, 2004), (Lee, Choi, & Lee, 2004), (Emmerink, Nijkamp, Rietveld, & Van Ommeren, 1996) and (Li et al., 2015)) pointed out that the follow up behavior of the VMS depends on the following factors: the content of the message shown, the local circumstances, driver characteristics, readability of the VMS, possible travel time savings, delay time, and delay cause as most important attributes. The content of the message consists of the travel time, actual delay time, location and cause of the delay. The simpler and shorter the text the better understandable it is for the road users; preferable with the use of pictorial symbols. Based on the content of the VMS, drivers make their decision. Displaying travel time on VMS when no delays are occurring is pointed out by drivers to be stratifying and securing. Research from Soekroella (2014) and Chatterjee & Mcdonald (2004) found that the road users described the presented information on the VMS as clear and useful. And most drivers agreed on the fact that the information is trustworthy and that the road users get the feeling that the VMS improve their safety and travel time savings. However, these route users did not all deviate from their route. Whereas the road users pointed out that there were no alternative routes available for their final destination. The majority of the drivers do not take the alternative route when it is not perceived faster than the original route or that the increase of travel time of the original route is not significant enough. Knowing the actual cause of the delay has a beneficial effect on how and when people react towards the presented information. Again this is colliding with the availability of viable alternative routes which avoid the problem location. These causes to take alternative routes are delays by an accident or construction roadworks (Lee et al., 2004).

Still there are sceptic road users toward the reliability of the VMS traffic information presented. That the information is presented in an understandable format and accepted by the road users does not mean that it provides comfort. As Lee et al. (2004) found that there are several mixed feelings to the reduced stress by the VMS. Also research of Rijkswaterstaat showed the phenomenon of stress increase, often in correlation with the guidance information being not obvious for all road users. The road users get stressed or insecure by the presented information and do not know which correct route to select. As an example, the road users know that there is a delay but they often do not know what alternative route to take. Especially when being unknown with the traffic network area, causing extra stress. However, the GRIP which is a VMS variant is proven to be more reliable in this kind of situation. This is mainly because of the visualization of the alternative routes. The GRIP shows that the routes will eventually merge back together which gives confidence in taking the route and providing the possibility to adapt their choices at a later moment in time (van de Pas et al., 2012).

4.2.2 Road users' behavior towards in-car traffic information systems

The behavior of road users towards in-car traffic information is not yet researched by as many researchers as the VMS roadside systems. This is because of the fact that the in-car systems are still more evolving and fairly 'new', except for the radio traffic information system.

The radio traffic information system is as mentioned in earlier paragraphs, one of the oldest in-car systems that provide traffic information. Aside from the way of presenting the information by radio, a fact came to the light by Emmerink et al. (1996). Who pointed out that radio traffic information increases the level of satisfaction when the alternative route remains on the motorway and/or that the alternative route is not much longer than the original route.

The newer in-car systems such as the navigation systems and smartphone apps provide certain benefits to the users. Personal based traffic information is the major difference compared to the radio in-car system and road side systems. Aside from this difference the road users want to be able to select their own possible route alternatives and customize their own display for their needs (Khattak et al., 1993). These customizations consist out of visual displays and audio-based presentations. It is shown that audio presented information is experienced as more useful and requires less mental effort whiles driving than text messages. Brookhuis & Dicke (2009) found that by presenting the information with the use of audio messages the drivers focused more on the road than on the display screen. Van Rooijen et al. (2008) showed with their research that road users while travelling with a navigation system which both has audio and visual display reach their destination to an unknown area faster. But it was more importantly that the workload while driving was lowered. This indirectly causes a positive effect on the traffic safety when the information was presented at correct times.

Navigation systems are often used during less frequent and long trips to unknown areas. During these trips the road users have the option to deviate from the suggested route by the navigation system. The most important reason to deviate is because the road user knows a better alternative for the suggested route. Or he/she knows that there is a possible traffic jam or roadworks ahead of the route (Schaap et al., 2015). These decisions are based on their own knowledge or by additional information gained by the radio traffic information and VMS information. Schaap et al. (2015) found that road users use the VMS and radio actively for additional information that is not presented by the navigation system.

In general, presenting the in-car traffic information also stated by van de Pas et al. (2012) is more effective than road-side information related toward behavioral changes. But it is also more dangerous, because some in-car systems can cause distraction. It is therefore important to only present relevant and important information at times that the road user can spend attention to that specific information.

4.3 Conclusion

Which characteristics are most influential for road users in route deviation behavior?

How do people act based on the traffic information streams?

All the road users have different skills and views on traffic information and guidance, a general road user does not exist. The opinions of the road users are still scattered towards the fact of perceived usefulness of the DRIP(s). Following the suggestions that are displayed depends in the Netherlands mostly on the circumstances, causes of the delays, and the availability of alternatives routes.

Road users want to know the actual traffic situation, consisting of what the exact problem is with a certain delay occurring on the route. It is needed to present them with the duration of the delay and possible alternatives. If possible, this information needs to be presented as personalized as possible to reach the most positive effect towards the road user's behavior. Presenting the information personalized with a low workload has a positive behavioral effect on the road users. The time of receiving the knowledge and the pre-know knowledge from earlier trips has influence on how road users act towards gained information. It is best to present the information that fits to a certain situation, which is often done by in-car systems. However, the in-car systems can cause potential unsafe situation due to distractions.

5. STATED CHOICE EXPERIMENT

This chapter describes the methodology that is used during the graduation research. First, the theory behind the way of modelling the choice experiment is briefly discussed. This is followed by the roadmap of setting up the stated preference experiment and some details of the models used to analyze the gathered data.

5.1 Setting up the stated choice experiment

A stated-choice experiment is set up to gain knowledge on car drivers' route choice decisions at unbundled highways and the influence of travel information presented while driving. It is important to figure out what the preferences of car drivers are towards different traffic information media whiles driving in different circumstances. Stated preference (SP) is used over revealed preference (RP) for this choice experiment. RP relates to situations where the choice is made in real-life situations, which is in contrast with SP were the choice is made in a controlled hypothetical environment (Hensher, Rose, & Greene, 2015). The advantaged on the controlled situation described with SP is that the attributes can consists of different levels and data can be gathered that is not available when using RP. Collecting data with the use of SP allows future applications to be taken in consideration and collect data of complex and rare (not existing) situations.

The challenge of this research is to identify, capture and use as much of the information that an individual takes on board when they process a situation leading to a choice (Hensher, Rose, & Greene, 2015). It is important to find out what a whole population of individuals prefers when choosing an (route) option. The choice behavior of individuals is often based on the perception and evaluation of their physical, functional and social-economic attributes. With this approach it will be possible to determine which (combinations of) attributes are important for the whole population. SP is unique in a way that only the choice response variable is provided by the respondent after evaluating all the attributes in a certain scenario.

Setting up a stated preference experiment is done with the use of the roadmap towards a choice-experiment presented by Hensher, Green and Rose (2015). All the steps are shown in figure 12. The plan consists of in total eight stages, the main steps are described in the next paragraphs starting with the problem definition followed by selection and defining the attributes.

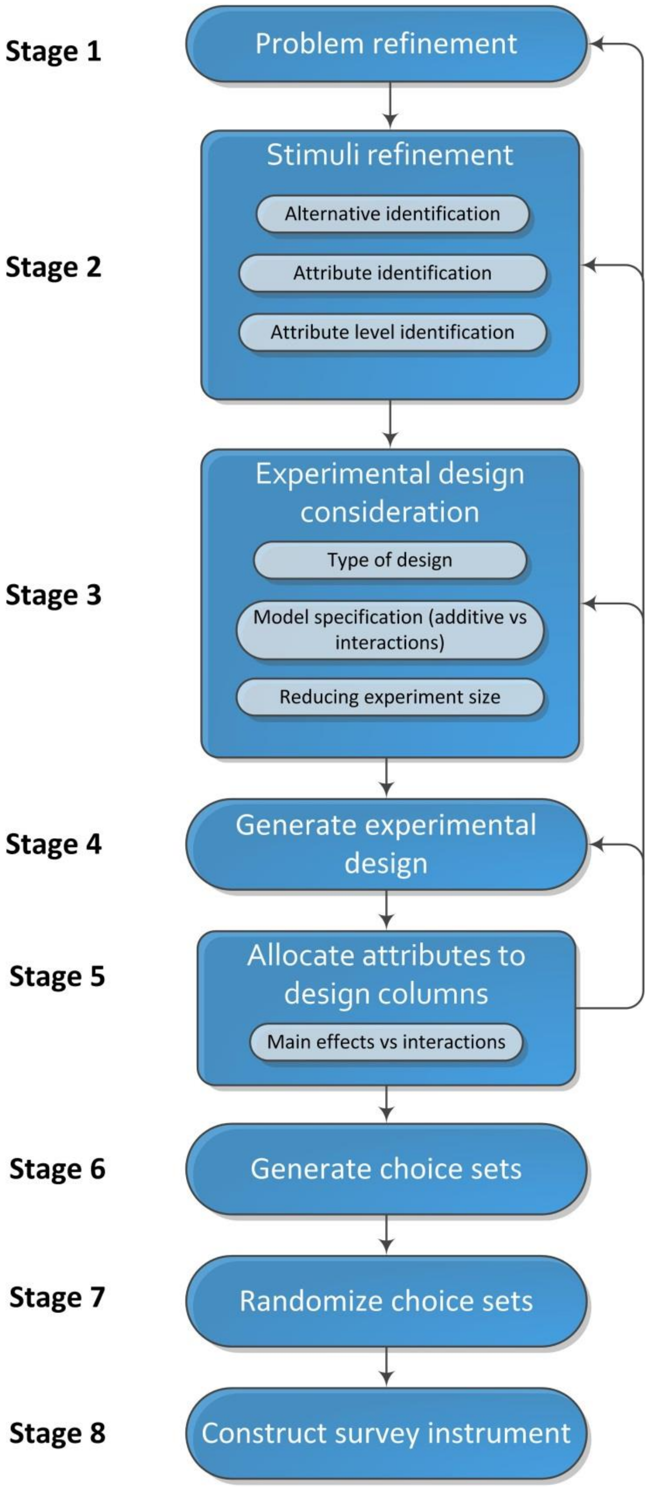


Figure 12 Choice-experiment stage plan (Source: Hensher et al., 2015)

5.1.1 Research problem refinement

The stated preference experiment should be based on the main research question and problem focus:

Which context and road related attributes influence the route choice behavior of car drivers at unbundled highways with the presence of different traffic information systems?

With the focus on unbundled highways where the situation of a regional road and parallel local traffic road applies. Regarding the travel information, the focus is on three main information media, DRIPs, in-car navigation system with real-time traffic information, and radio traffic information. The currently booming smartphone applications are not taken in consideration because of the high amount of different kind of applications on the market right now. The varieties of apps makes it hard to visualize one specific app, since one app can have several different functions. The current navigation apps for smartphone that show on-route real-time traffic information are comparable with current navigation systems with real-time traffic information.

5.1.2 Stimuli refinement

The focus of this experiment is on highway roads including a regional road and a parallel local road as alternative. These alternatives are described with the use of labels. Labeled alternatives are preferred over unlabeled alternatives which are only defined with combinations of attributes. Labeled alternatives offer the opportunity to study the important role of alternative-specific constants (Hensher et al., 2015). The labels used here are the 'A-route' and 'N-route'. The A-routes consists only of A-roads. A-roads in the Netherlands are the main highway routes for regional traffic through the county, whereas the N-roads are the more local connected roads for the local traffic. Respondents already have their own vision of the meaning of these roads, but to create a clear view on these alternatives some attributes of the A-route and N-route are added in table 2. The labels and attributes of these alternatives are fixed for every scenario described later on in paragraph 5.1.4.

Table 2 Attributes A-route and N-route

Attribute name	***A-route***	***N-route***
Type	Regional traffic	Regional and local traffic
Maximum speed	120 km/h	80 km/h
Number of traffic lanes	2 + emergency lane	2 + emergency lane
Extra information	No exits until the next intersection	Several exits until the next intersection

The attributes which have different attribute levels are carefully selected and narrowed down to twelve attributes. The rather large amount of interesting attributes was narrowed down to the number of twelve because of the complexness of using too many. The twelve selected attributes are selected to keep the situations corresponding to real life situation as much as possible. Still the situations are hypothetical and it is uncertain if people would act the same way if the situation was presented in real life. This remains one of the questionable parts of a SP experiments as discussed earlier.

The twelve attributes are selected after extensive literature review of previous studies that focused on route deviation and route choice research with the use of VMS. The sources of these attributes can be found in Table 3. The attribute levels are defined for this specific research with the use of the literature study and feedback from expert in the field of traffic management at RWS. Eight out of the twelve attributes consist of three level attributes and the remaining attributes consist out of two attribute levels. There is a low correlation between the two level attributes which can be seen in Appendix I. Nine of the attributes with their corresponding levels and labels are displayed in Table 3 at the next page.

Some special noteworthy attributes that are not researched by researchers before are the alternative bound attributes:

- The amount of Truck Traffic at the A-route
- The number of Exit Lanes at the N-route

These two attributes are taken into consideration especially for this research due to the fact of the difference between the A-route and N-route. The attributes are alternative specific attributes. ‘Truck Traffic’ at the A-route, is the percentage of total traffic amount at a certain moment in time on the A-route, defined by three levels. Truck traffic is chosen for the A-route only because truck drivers have a strong preference for highway as well as a strong dislike of local roads (Arentze, Feng, Timmermans, & Robroeks, 2012). The attribute ‘Exit Lanes’ at the N-route is chosen because of the aspect that N-roads do have exit lanes between intersection points in contrast to the A-roads at many city bypass road in the Netherlands. The exit lanes provide an extra driving task for the road users including the task of interacting with the weaving traffic.

Only nine out of the twelve attributes are discussed. The three remaining attributes are related to the traffic information media; DRIPs, navigation systems and radio. The attributes corresponding to these information media are two levelled. The two levels consist of the system either being ‘active’ or ‘inactive’ as shown in Table 4. These two levels offer the opportunity to create different scenarios all with the same alternatives; A-route and N-route, which have their own fixed attributes. A certain combination of these attributes and unique attribute level are called treatment combinations. Treatment combinations describe the profile of the alternatives scenarios (Hensher et al., 2015). The creation of these scenarios will be more thoroughly discussed in paragraph 5.1.4.

Table 3 Selected attributes with attribute levels

Attributes	Levels	Labels	Source
Section Start Time	1	Morning peak hours 6:00-10:00	(Arentze et al., 2012), (Khattak et al., 1993), (Xu et al., 2011)
	2	Non-peak hours	
	3	Evening peak hours 15:00-19:00u	
Delay Cause	1	Daily Traffic Jam	(Hong-Cheng Gan et al., 2013), (Wardman et al., 1997)
	2	Roadworks	
	3	Accidents	
Segment Distance (until the next intersection) 1	1	5 kilometer	(Li et al., 2015)
	2	10 kilometer	
	3	15 kilometer	
Segment Travel Time A-route 1	1	3 minutes	(Wardman et al., 1997)
	2	6 minutes	
	3	9 minutes	
Segment Travel Time N-route 1	1	4 minutes	(Wardman et al., 1997)
	2	8 minutes	
	3	12 minutes	
Bypass usage (familiarity)	1	Monthly use	(Bonsall & Joint, 1991), (Khattak et al., 1993), (Xu et al., 2011), (Wardman et al., 1997), (Ma et al., 2014), (Dai & Panwai, 2007)
	2	Weekly use	
	3	Daily use	
Truck Traffic A-route	1	Low amount (5%)	
	2	Normal amount (10%)	
	3	High amount (15%)	
Exit lanes N-route	1	2 Exit lanes	
	2	3 Exit lanes	
	3	4 Exit lanes	
Delay time A-route	1	0 minutes	(Hong Cheng Gan et al., 2013), (Lee et al., 2004), (Wardman et al., 1997)
	2	4 minutes	
	3	8 minutes	
Delay time N-route	1	0 minutes	(Hong Cheng Gan et al., 2013), (Lee et al., 2004), (Wardman et al., 1997)
	2	3 minutes	
	3	6 minutes	
Weather Circumstances	1	Clear vision	(Lee et al., 2004), (Khattak et al., 1993)
	2	Unclear vision	

1 Segment Distance is coupled with Segment Travel Time, considered as one attribute: Segment Distance

Table 4 Availability of Information Media

Attributes	Levels	Labels
Dynamic Route Information Panel	1	Active
	2	Inactive
Navigation system with real-time traffic information	1	Active
	2	Inactive
Radio traffic information	1	Active
	2	Inactive

5.1.3 Situation Choice-sets

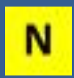
After the determination of all the attributes and the corresponding attribute levels, it is possible to generate different kind of situations. With the twelve attributes it is possible to create a total of 157.464 possible situations. This are way too many situations to take in consideration for this study and to present to the respondents. There are different ways to narrow this number down and still being representative for the total amount of possible situations. Fractional factorial design is used here and narrowed the total number of 157.464 possibilities down to 27 situations. These 27 situations still place a significant level of cognitive burden on the respondents. Which likely results in a decrease of response rate and/or a decrease in response reliability (Hensher et al., 2015). To avoid these matters the total set of 27 situations is divided in three separate sets of nine situations.

Discrete choice models require that each choice set consists of an exhaustive and finite set of mutually exclusive alternatives. These sets consist of random situations but evenly spread attribute levels. That means that one set does not contain all the situations with all the extreme attribute levels. The final sets with the corresponding attribute levels can be seen in Appendix II. The choice-sets are randomly selected and presented to the respondents. This is more thoroughly discussed in section 5.2.

5.1.4 Situation Presentation

Now that the total number of situations is set, the presentation of these situations needs to be designed. In Stated Preference surveys, the choice of levels of attributes characterizing choice alternatives must be done with great care (Perdomo, Rezaei, Patterson, Saunier, & Miranda-moreno, 2014). This can be done is several ways; verbally by text or speech, but also by visualization. For this research the presentation of the situations is done using visualization of a still image, additional text, and pictorial attributes. When possible the attributes are displayed as a pictorial image. These images need to correspond with the thoughts of the respondents. Table 5 contains all the used images. It is chosen to correlate the attribute images with used traffic signs in the Netherlands. However, this was not possible for all the attributes. The amount of truck traffic at the A-route and segment distance had to be visualized by the researcher. This was done with caution and tested in a pilot-survey to see if the respondents did understand the meaning of these images.

Table 5 Pictorial images used for some attributes

Pictorial Image	*Explanation*	*Pictorial Image*	*Explanation*
	A-route, associated with A-roads in the Netherlands		Exit lanes: one sign indicate a number of exit lanes.
	N-route, associated with N-roads in the Netherlands		Indicating the amount of truck traffic
	Speed limit signs 120 and 80 km/h		Segment distance length 5 km
	Delay cause: Daily traffic jam		Segment distance length 10 km
	Delay cause: Roadworks		Segment distance length 15 km
	Delay cause: Accident		

The traffic information media are important attributes in the situation designs, and therefore need to be designed with caution. The DRIP system is designed exactly as it is displayed at the side of the road. The visual design of the in-car systems is not that straightforward. Table 6 shows which information each media source has to show, this narrows the possibilities down in the visualizing the systems. The difference in information display by the traffic information systems is because it is tried to mimic and create copies of the already existing system on the market. However, the radio system is displayed as text since it is not possible to provide audio fragments for the radio system itself for each different scenario. The final visualization of each separate information system can be seen in Appendix III.

Table 6 Information displayed per traffic information medium

DRIP	Navigation System	Radio
Intersection Name	Fastest Route	Intersection Name
Travel Time segment	Travel Time Advantage	Delay Cause
Delay Time segment	Delay Cause	Delay Location
Cause of Delay	Delay Location	Delay Time

An important factor was to create situations that are close to real life situations. Therefore the visualization was done by creating an in-car perspective as shown in figure 13. The in-car visualization includes the traffic information media DRIP, Navigation system, and Radio, which are either active or inactive for each situation.

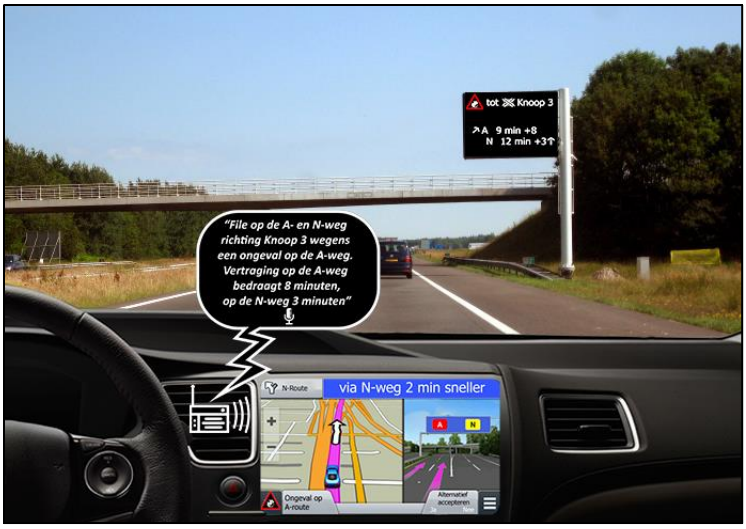


Figure 13 In-Car visualization with traffic information media

One of the attributes that is described earlier and potentially has influence on route choice behavior is the weather type. The 'unclear vision' and 'clear vision' levels are visualized in the in-car image, where figure 13 presents the 'clear vision' and figure 14 the 'unclear vision' with the use of a darker background and including rain. By creating the visualizations in the figures 13 and 14 the respondent can immerse into the actual situation. This is just half of the stated preference presentation. The route alternatives need to be added in order to make a decision, and the remaining attributes need to be added as well to complete the whole scenario.

Figure 14 Weather type 'Unclear vision' visualization

Section start time, segment distance, bypass usage, track traffic A-route and exit lanes N-route need to be included. There is chosen to visualize these attributes with icons when possible. This is done for all the remaining attributes except for the attributes 'section start time' and 'bypass usage'. These two attributes are displayed as plain text. All the images used per attribute can be seen in Appendix IV (Deel 2 Intro). Figure 15 displays the final layout for each separate situation description with an explanation displayed in the colored frames. This figure is also given before the start of the scenarios during the questionnaire. The set-up of the questionnaire is discussed in paragraph 5.2.1.

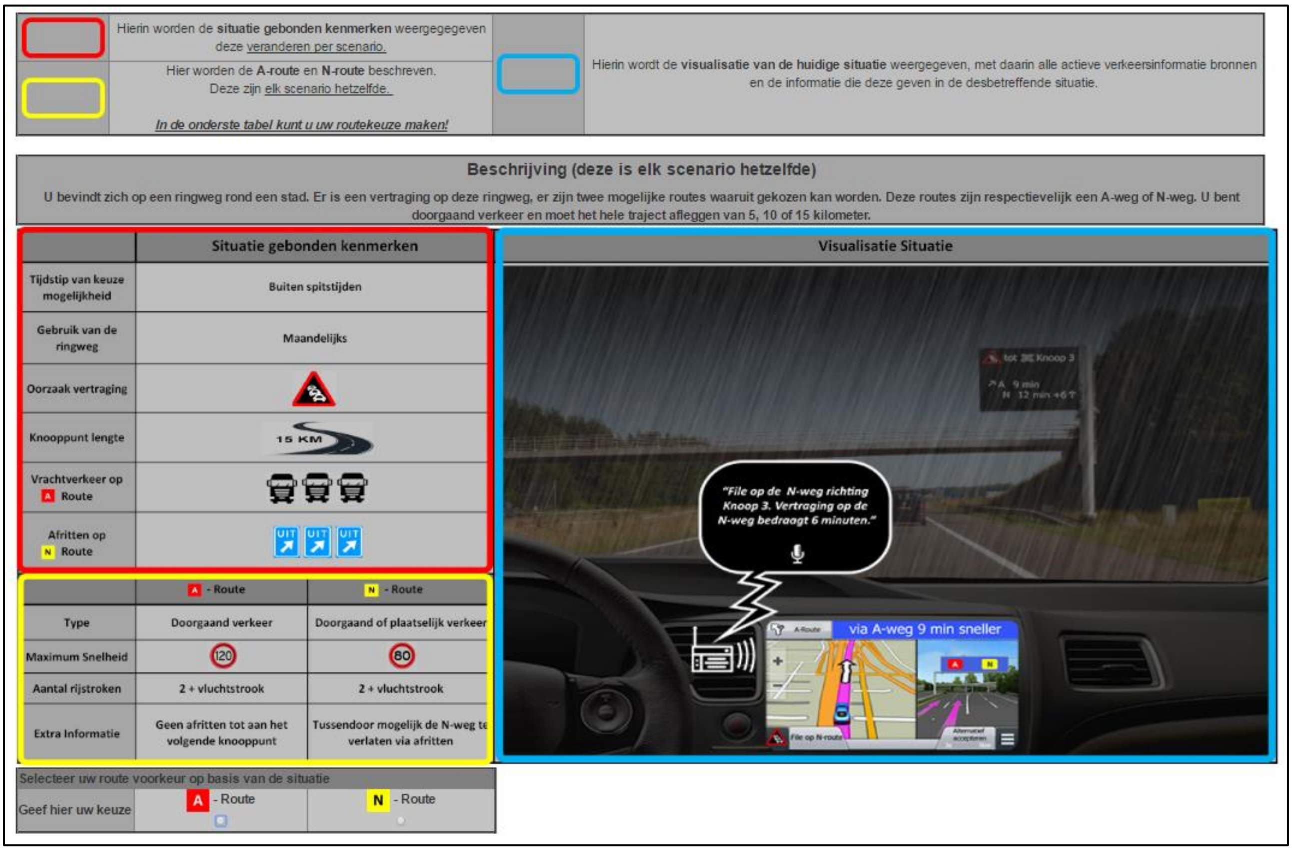


Figure 15 Final layout of the situation visualization and description

Every scenario starts with a short description of the situation in general. This is the same in every given scenario and is repeated as a reminder. The red colored frame displays the situation bound aspects, which will change for every scenario given to the respondent. The blue frame shows the visualization of the scenario with all the active traffic information systems and the specific traffic information that is displayed. The yellow colored frame provides the same information as given in Table 2 with the additional visualization of the maximum speed limit and the A and N road signs. Finally, after processing all the information the final route choice can be made. This is displayed in the lower table of figure 15, which is either the A-route or N-route. There is chosen not to visualize other messages on the DRIP traffic information system such as “Bob jij , of Bob ik.” These messages often contain campaign information which are presented to stimulate the traffic safety. Previous research from RWS has shown that people are annoyed and distracted by such messages (Rijkswaterstaat - Adviesdienst Verkeer en Vervoer, 2007).

5.2 Data collection

This section covers the steps that are made in setting up the questionnaire used to collect the data. The distribution of the questionnaire is done by several online means, which are described in paragraph 5.2.2.

5.2.1 Questionnaire set-up

For this choice experiment, the data is collected using an online questionnaire system, ‘Berg Enquête System 2.2’, this system is designed by the TU/e and offers the opportunity to spread the questionnaire online. The questionnaire consists out of three different parts; each part is described in Dutch. The three parts of the questionnaire consist of an easy part, followed by a more complex second part containing the choice experiment, and finishing off with an easy part containing socio-demographic questions.

The first part of the questionnaire covers questions about the driving behavior, the respondent’s awareness and familiarity with DRIPs, and the usage of other traffic information systems. Table 7 on the next page shows all the questions and the corresponding levels. The second part of the questionnaire covers the situations of the choice experiment. First the information media are introduced and the containing information is explained in more detail. This is followed by the alternatives with their attributes and extra containing information. Lastly, the remaining attributes that change in each situation are explained and visualized if applicable. The visualization of these attributes was done to lower the information load. By visualizing these attributes an additional explanation of each visualization is required to give the meaning of the visualization, these can be found in Appendix IV page 89 and 90. After the general explanation of the experiment, the respondents get an example question containing the table with a certain

Table 7 Driving and traffic medium experience

Attributes	Levels	Labels
Highway Usage	1	Never
	2	Less than ones per month
	3	1 - 3 times per month
	4	1 time per week
	5	2 – 3 times per week
	6	3 times or more per week
On the road for work	1	Never
	2	Sometimes
	3	Regularly
	4	Often
	5	Always
Average Annual Mileage	0	I don't know
	1	Less than 5000 kilometers
	2	5000 – 9999 kilometers
	3	10.000 – 19.999 kilometers
	4	20.000 – 29.999 kilometers
	5	30.000 kilometers or more
Seen Drips	1	Never
Read Drips	2	Sometimes
Trust Drips	3	Regularly
Route based on Drips	4	Often
	5	Always
Usage of systems:	0	False
Navigation system	1	True
Navigation system with live updates		
Radio		
DRIP		
Smartphone Application		
Internet website		
Teletext		
Differently (open text)		
Systems owned:	0	False
Navigation system	1	True
Navigation system with live traffic updates		
Smartphone Application		
Radio		
Differently (open text)		
System usage during trips:	0	False
Same systems as owned	1	True
Importance towards certain information	1	Very little
streams:	2	little
Fixed travel time	3	Average
Shortest route	4	Much
Fastest route	5	Very much
Familiarity with the route		
Important route deviation reason	1	Daily traffic jam
	2	Accident
	3	Roadworks
		Differently Namely

scenario. This example question is shown in figure 15. The choice experiment is divided in three different sets of nine randomly selected scenarios. The sets are randomly distributed across the respondents. Combining three respondents provide a full set of the 27 different situations, the situations containing in each set are found in Appendix II. Set one is covered 78 times, set two 83 times, and the third set 81 times (before data cleaning). The respondents are asked to choose their preferred route for each separate scenarios based on the given attribute levels.

Part three is the last part of the questionnaire and aims to gain some background information of the respondents. This part contains a few socio-demographic related questions. All the attribute levels are shown in Table 8. The background information of the respondents is important and used in combination with the stated preference experiment results. The characteristics describe the socio-demographic profile of each sampled trip maker (Hensher et al., 2015). Having this data gives a lot of information about the characteristics of the respondent towards the choice behavior. The full survey can be found in Appendix IV.

Table 8 Socio-demographic questions used for the questionnaire

Attributes	***Levels***	***Labels***
Gender	1	Male
	2	Female
Age	0	Open Question
Education	1	Primary Education
	2	Secondary Education
	3	Lower Education
	4	Higher Education
	5	University
	6	No Education
Driver's license	1	Yes
	2	No
Driving experience in years	0	Open Question

5.2.2 *Questionnaire distribution and sample size*

The distribution of the questionnaire is done using online means. By spreading the questionnaire online many people could be reached and asked to fill in the questionnaire in a relatively short period of time. The advantages of an online questionnaire are that it is fast and effective in reaching many people in a short period of time. The online questionnaire provides the respondents with the opportunity to decide when they want to start the questionnaire. The total duration of one questionnaire is set to around 10 to 15 minutes which is in the perfect range accordingly to Galesic & Bosnjak (2009). Reaching the respondents online is done with the use of direct mailing and sharing a link of the questionnaire on social media platforms such as Facebook and LinkedIn. However, most people reached on the social media platforms are either relatives or acquaintances. This can result in partly biased results. The respondents reached by direct mailing are former participants from earlier studies at the TU/e, and e-mail addresses from the researchers personal address book. However, the link to the questionnaire is also spread by the respondents themselves to reach more people. The total amount of people that received the questionnaire is therefore not known. In other words the response rate of the questionnaire is not known.

The appropriate sample size can be calculated with a general rule of thumb which was proposed by Orme (1998) (Rose & Bliemer, 2013). The formula is specific for SC experiments and shown in equation 5.1.

$$N \geq 500 \cdot \frac{L^{max}}{J \cdot S} \tag{5.1}$$

Where,

N	is the desired sample size
L^{max}	is the largest number of levels of the used attributes
J	is the number of alternatives included in a choice-set
S	is the number of choice-sets in the experiment

For this experiment the maximum attribute level used was$L^{max} = 3$, the alternative included in a choice-set was$J = 2$. And the total number of choice-sets for this SP data collection was $S = 3$. Using the Orme rule of thumb a total of 250 respondents is needed. In total there were 460 people who started the survey, 246 respondents completed the first part or more. Resulting in 238 fully completed surveys and 2 incomplete but with all the scenarios completed. Eventually, the results were used that had respondents over 18 years of age and with a valid driver's license[8] resulting in a total of 231 respondents for this convenience sample. This number is slightly under the Orme rule of thumb amount of 250, but it are still enough respondents for this study.

5.3 Data analyses

This section explains which methods are used to analyze the data and why these methods are used for this research. During the analyses the confidence level of 90% is used to still provide useful and representative results.

5.3.1 Descriptive analysis

The descriptive analysis is an important way of presenting the data. The main objective is to transform the raw data to more understandable formats which can be interpreted quickly. Creating a more understandable format can be done by ordering and rearranging the data, and even manipulation if necessary. The gathered data consist out of nominal and ordinal scaled data, other possible data formats are interval and ratio data. The data can be

[8] Driver's license 'rijbewijs B' is in the Netherlands the minimum required license to drive a car.

presented with in tables and visual means. During this research the descriptive analyses is mainly done with the use of the software package SPSS.

Most questions in the survey are asked on a five points based scale, which can result in a lower amount of answers on one scale answer. It is possible to combine several levels, and create a new three level scale previous five level scale questions.

Comparing the descriptive results from the this research with other studies towards the same subject or with data from organizations such as the CBS is useful to see if the sample group can be compared to the total population. In the case of this research it would be the Dutch population. Comparing the data to highway users was expected to be more optimal but that data was not available.

Aside from the comparisons it is important to list all the essential and relevant variables including control variables. Additional information about the means, standard deviations and number of respondents is also needed. This information is important and necessary when others want to reproduce the results, or do secondary analyses with the dataset (Bedeian, 2015).

5.3.2 Multinomial logit model

The Multinomial Logit Model (MNL) is used to estimate the parameter from the stated preference experiment. In the 1970s, the Multinomial Logit Model (MNL) got improved and finessed based on the MNL model created by Dan McFadden in 1974. The multinomial logit model is used for the second part of the survey which consisted of the choice experiment. MNL is a regression analysis technique which is used to analyze relationships between a non-metric dependent variable and one or more metric or dichotomous independent variables. MNL is one of the most used methods and the foundation for the analysis of discrete choice modeling of this kind.

One of the limitations or possible setbacks in using this method will first be discussed before continuing with the model method itself. The major limitation is the assumption of independence form irrelevant alternative (IIA). (Cheng & Long, 2007) IIA means that a persons' choice between two alternative outcomes stays unaffected by the other choices that are available. Train, (2003) pointed out that the IIA does not only apply to the choices, but it can also occur for a specification of the independent variables. There are different ways to test the IIA. One of them is the likelihood ratio test, which is described later on. The other two tests are the Small and Hsiao test, and the Hausman and MacFadden test, which are most often used (Cheng & Long, 2007). If IIA is applicable the use of the Nested Logit model is suggested to present a partial relaxation of the IIA (Hensher et al., 2015).
There are two different sorts of effects: main effects and interaction effects. Main effect is an effect of one of the independent variables with the dependent variables. The effect on the experimental response of going from one level of the variable to the next level other given that the remaining variables do not change (Sanko, 2001). Every independent variable

used in this research has a possible main effect that can be looked at. An interaction occurs when one effect on an independent variable on the dependent variable changes another independent variable. During this research the dependent variable used is the route choice: A-route or N-route.

Multinomial logistic regression compares multiple groups through a combination of binary logistic regressions. The classical MNL model is used. The model itself is briefly discussed. Index *q* is the index for the respondent (1,…,Q); index *i* is the route alternative (*i= 1,…,I)* (Eluru, Chakour, & El-Geneidy, 2012). The MNL model assumes each individual *q* associates an utility with each alternative route *i.*

$$U_{qi} = V_{qi} + \varepsilon_{qi} \tag{5.2}$$

The MNL model assumes each individual *q* associates a utility to each alternative *i* and that this can be separated into an observed part and unobserved part.

Where,

U_{qi} is the utility of alternative *i* of individual *q;*

V_{qi} is the structural utility, which is the observed part;

ε_{qi} is the unobservable part which is unknown and often treated as random.

It can be said that every respondent will carefully judge all the alternatives to a certain value, which is the utility and based on the highest utility the respondent will choose the alternative that provides the most benefits. It is possible with the use of MNL to predict the probability that an individual will choose one alternative over the other alternative from the choice-experiment. Which gives the formulas in equation 5.3 and 5.4 (individual *q* choosing alternative *i* over alternative *j* (Train, 2003)).

$$P_{qi} = Prob\left(V_{qi} + \varepsilon_{qi} > V_{qj} + \varepsilon_{qj}\right) \tag{5.3}$$

$$P_{qi} = Prob\left(\varepsilon_{qj} < \varepsilon_{qi} + V_{qi} - V_{qj}\right) \tag{5.4}$$

The utility representation for the model is determined with the equation given in 5.5.

$$V_{qi} = \sum \beta_n x_{qin} \tag{5.5}$$

Where,

β_n is the parameter representing the weight of attribute *n*

X_{qin} is the score of an alternative *i* on attribute *n* for the individual *q*

This equations combined can be rewritten into finding the probability that an individual *q* chooses alternative *i* in Equation 5.6 (Train, 2003) (Sungyop Kim & Ulfarsson, 2008).

$$P_{qi} = \frac{e^{V_{qi}}}{\sum_j e^{V_{qj}}} \tag{5.6}$$

5.3.3 Effect coding

All the attributes used in the model are categorical and need to be recoded to make it possible to compare them with each other. The coding technique used here is effect coding. Effect coding is chosen because after the coding the gained results can be interpreted directly. There are two levelled and three levelled attributes used during this research which have the coding shown in table 9. Effect coding has the advantage of showing effects which are uncorrelated with the intercept (Bech & Gyrd-hansen, 2005). The coding is done as shown in table 9, were the reference level is coded as -1 for two level attributes and -1 -1 for three level attributes. The utility of the L_{th} level equals $\beta_1 * (-1) + \beta_2 * (-1) + \ldots + \beta_{L-1} * (-1)$, this means that the reference point is internalized in the β estimate. This way the constant term can only reflect the utility associated with the fixed comparator (Bech & Gyrd-hansen, 2005).

Table 9 Effect coding (Source: Bech & Gyrd-hansen, 2005**)**

Attribute levels	***Two level***		***Three level***		
	Indicator 1	***Utility***	***Indicator 1***	***Indicator 2***	***Utility***
0	1	β_1	1	0	β_1
1	-1	$-\beta_1$	0	1	β_2
2			-1	-1	$-(\beta_1 + \beta_2)$
Parameter	β_1		β_1	β_2	

5.3.4 Model quality tests

This paragraph will go through the basic knowledge on how to check if the used model is viable, in other word if the model fits the observed data. There are different test to validate if this used model with estimations is better than the model without estimations. The log likelihood, likelihood ratio, R-square and Chi-square are discussed in this order.

Log likelihood

The goal of a researcher is to find the unknown parameters β. The *log-likelihood (LL)* is defined in such a way that it maximizes the prediction obtained by the model (Hensher et al., 2015). The choice models are often estimated with the use of a *LL*. The value of the *LL* goes down when adding restrictions. MNL models assume that the choice observations are independent over all decision makers and choice situations. Equation 5.7 shows the LL_β for the estimated model and equation 5.8 shows the LL_0 formula.

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i} y_{ni} \ln(P_{ni}) \tag{5.7}$$

Where,

LL(β) is the log likelihood of the proposed model with the estimated parameter of β;

N is the total sample size used in the model;

y_{ni} is the choice of one individual *n* made for an alternative *i* which can be 1 or 0;

P_{ni} is the probability of the individual *n* choosing alternative *i.*

$$LL(0) = \sum_{n=1}^{N} \sum_{t} \ln \frac{1}{J} \tag{5.8}$$

Where,

LL(0) is the log likelihood of the null model with all parameter of β=0;

N is the total sample size used in the model;

J is the total number of alternatives in choice-set *t* for individual *n.*

Log Likelihood ratio

The log likelihood ratio is one way of testing the used model compared to the null model. Also checking if the used model is a significant improvement over the null-model, with the parameters set to 0. Equation 5.9 by Train (2003) show how this can be calculated.

$$D = -2\left(LL_0 - LL_{\hat{\beta}}\right) \tag{5.9}$$

Where,

D is the log likelihood ratio;

LL_0 is the null-model log likelihood, with all the parameter zero;

$LL_{\hat{\beta}}$ is the proposed model log likelihood, with the estimated parameters of β.

The log likelihood ratio can be compared to the value given in the chi-square table with the degrees of freedom difference between the models for a certain confidence range. If the *D* is larger than the chi-square ratio value at a certain confidence interval the assumption will be rejected. If the *D* value is lower than the chi square it can be concluded that the estimated model is not better than the base model (Hensher et al., 2015). If the LL_0 is used for the same two alternative models, the model with the highest ratio value can be interpreted as the model that fits the data best.

R-square

The R^2 from Mcfadden (1974) is used to check the overall fit of a linear regression model, for a choice model the R^2 is not exactly the same. Because the MNL model in an underlying choice analysis it is not linear (Hensher et al., 2015). To calculate *the pseudo-R^2* the equation in 5.10 (Train, 2003) and (Hensher et al., 2015) is used.

$$R^2 = 1 - \frac{LL_{Estimated\ model}}{LL_{Base\ model}} = 1 - \frac{LL(\widehat{\beta})}{LL(0)} \qquad (5.10)$$

Where,

R^2	is the pseudo-R^2, which shows the level of improvement over the null-model;
LL_0	is the null-model log likelihood, with all the parameter zero;
$LL_{\widehat{\beta}}$	is the proposed model log likelihood, with the estimated parameters of β.

The value of the R^2 lies between 0 and 1. If the decision makers' choice can be predicted perfectly the R^2 is equals 1. The value a *pseudo-R^2* should represent to give a decent model fit is at least 0.1 for a discrete choice model. *Pseudo-R^2* values between 0.2 and 0.4 give a good fit. (Hensher et al., 2015).

Chi-square

The Pearson Chi-square test is one of the most common used tests for statistical analyses in evaluation and social science research (Franke, Ho, & Christie, 2012). It is used to find the indecencies between two categorical variables or to assess how well a certain sample fist the know population, in other words the goodness of fit. However the chi-square test is used for three different purposes: goodness of fit, independence and homogeneity. The formula for the Karl Pearson family of chi-square test is shown in equation 5.12 (Franke et al., 2012).

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \qquad (5.11)$$

Where,

n	is the number of cells in the table;
χ^2	is the chi-square;
O_i	is the observed data from the i^{th} observation;
E_i	is the expected data for the i^{th} observation.

The test which compares the sample on a variable against the population with known parameters is the goodness of fit test. The independence test determines if the two categorical variables from a single sample are either associated or independent from each other. This could be for example the driving experience and the selected route alternative. The third and last possibility can provide insight in the fact of homogeneity, which is commonly used to compare two or more groups on a categorical outcome. Often used in research towards medicine, where two groups are compared with each other (Franke et al., 2012). The test statistic resulting from the formula is used to compare it against a critical value from the chi-square distribution with *(r – 1)(c – 1)* degrees of freedom (Franke et al., 2012). Eventually the goal is to find a low as possible value for the chi-square test. This chi-square test formula given in equation 5.11 is used for the descriptive analyses.

5.4 Results

This section presents the final results from the data gathering and the estimated MNL models. The section starts with the descriptive analyses showing the composition of the sample. Next several MNL models are presented.

5.4.1 Descriptive analysis results

The composition of the sample is going to be discussed with the help of figures and the results are shown in table 10. The results are based on the completion of 231 questionnaires. The gender distribution in the questionnaire is a bit skewed and resulted in 173 males and 58 females shown in table 10. This this might be caused by the distribution among the own network of the researcher. It is also the known fact that more males tend to drive more often and use the highway intensively compared to women. The results are compared to CBS data based on the whole Dutch population. The gender distribution can be found in appendix V. It showed that the gender distribution differs from the whole Dutch population, which is divided by 50/50. However, it would be better to compare the gender distribution with the gender distribution of highways users only, this data was not available.

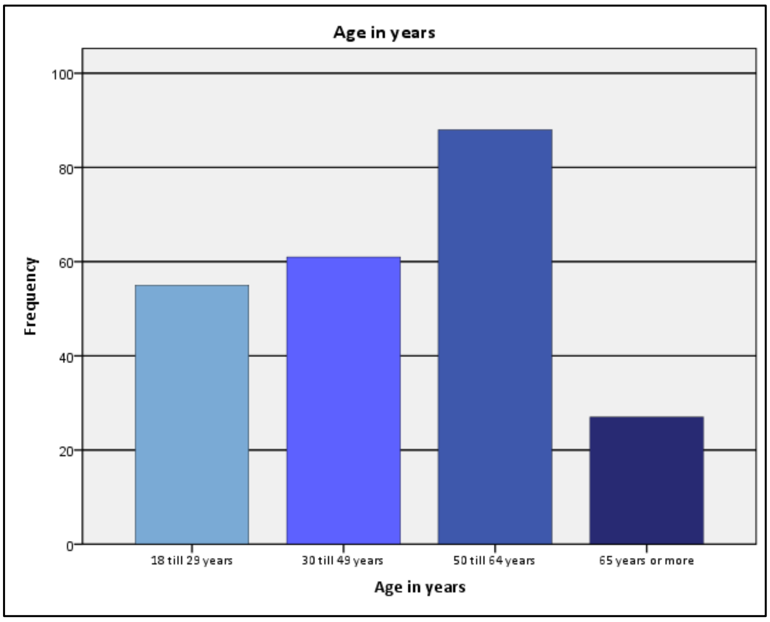


Figure 16 Categorical distributed age with frequencies

The average age of this survey is 46 years. Figure 16 shows the categorical distribution of the age groups. The respondents under the age of 18 are not taken in consideration due to the fact of not having a driver's license. Therefore, they are not eligible to choose an alternative route while driving in real life situations. The age distribution is compared to CBS data and categories of 2015 and can been seen in Appendix V. The age group of 20 years and younger is percentage wise lower as the CBS results because people younger as 18 are not taken in consideration for this research. The age group of 40 to 65 years only is percentage wise higher for this research compared to the Dutch population in 2015. This sample is then not a optimal representation of the Dutch population, but yet again it could be better compared with a highway user sample.

Table 10 Sample group characteristics with frequencies and percentages

Sample group characteristics

		Frequency	Percentage
Gender	Male	173	74,9%
	Female	58	25,1%
Age in years	18 till 29 years	55	23,8%
	30 till 49 years	61	26,4%
	50 till 64 years	88	38,1%
	65 years or more	27	11,7%
Education			
	Primary Education	2	0,9%
	Secondary Education	17	7,4%
	Lower Education	48	20,8%
	Higher Education	86	37,2%
	University	77	33,3%
Driving Experience in years	5 years and less	33	14,3%
	6 till 9 years	18	7,8%
	10 till 19 years	35	15,2%
	20 till 29 years	27	11,7%
	30 years or more	118	51,1%
Average Annual Mileage	I don't know	7	3,0%
	Less than 5000 kilometers	40	17,2%
	5.000 - 9.999 kilometers	39	16,8%
	10.000 - 19.999 kilometers	65	28,0%
	20.000 - 29.999 kilometers	38	16,4%
	30.000 kilometers or more	43	18,5%
Usage of the Highway	Never	0	0,0%
	Less than ones a month	20	8,6%
	1 till 3 times per month	45	19,4%
	1 time per week	38	16,4%
	2 till 3 times per week	40	17,2%
	3 times or more per week	89	38,4%
On the road for work	Never	71	30,6%
	Sometimes	65	28,0%
	Regularly	35	15,1%
	Often	37	15,9%
	Always	24	10,3%

The respondents were asked to fill in the importance level of certain route information and information presented by a traffic information system. Figure 17 displays the results of the: familiarity with the route, the fastest travel time, the shortest route, and the display of a fixed travel time. For example, the ‘familiarity with the route’ is given an ‘high’ rating by the respondents. Which indicates that the familiarity with the route has an high level of importance while making a route choice. The most answered values are cut out of the pie-chart and show that the familiarity with the route, the fastest travel time and the know travel time before travelling is valued with a high value. On the other hand the shortest route is labelled with a low value. It is noteworthy to mention that female respondents in this research had an evenly spread opinion choosing the shortest route, giving it an ‘average’ rating compared to men which gave it a ‘low’ ranking.

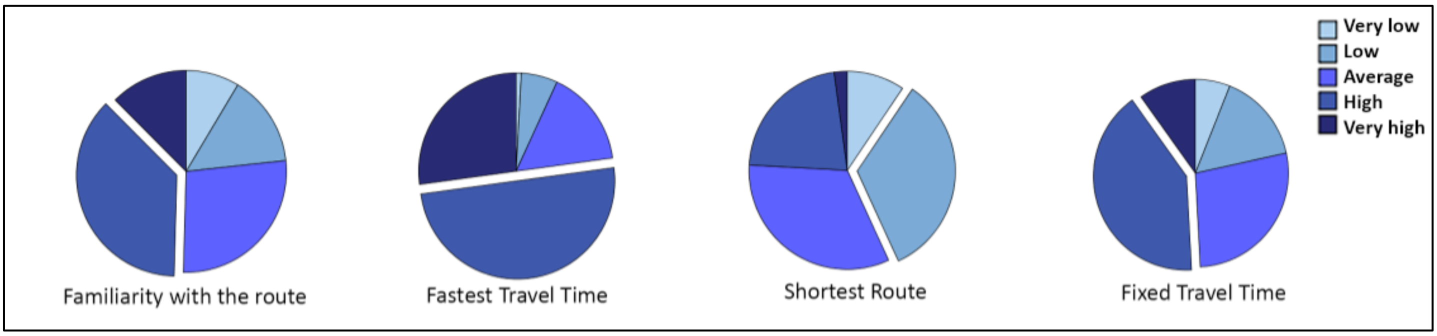


Figure 17 Value towards traffic information and route convenience

There were also some DRIP specific questions included in the survey. Out of the 231 respondents that filled in the questionnaire, 70 say on beforehand that they use the DRIP in general to gain traffic information. Figure 18 shows the DRIP interpretation filled in by the respondents. What can be seen from this figure is that the respondents see the DRIPs, read the DRIPs and often trust the DRIPs but only ‘sometimes’ till ‘never’ deviate from their route based on the information seen on the DRIPs by their own perception. These results correlate with results from previous studies.

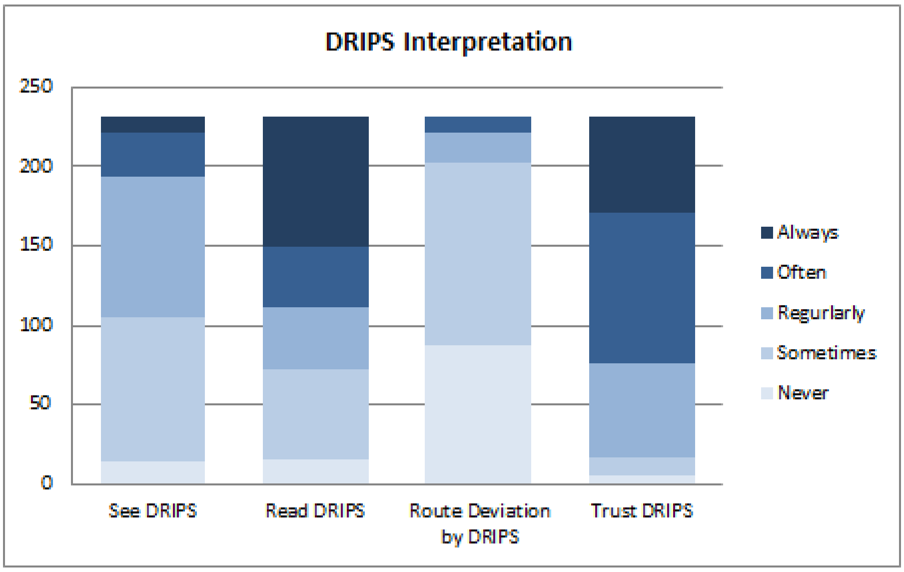


Figure 18 DRIPS interpretation of the sample group

The in-car traffic information systems are evaluated by asking the respondent three different questions. Firstly is asked if the respondents own any of the systems, then if it is asked if the systems used in general while travelling. This question is followed by the question if the respondents use certain traffic information systems during a trip on the highway. The results of these questions are clustered and displayed in figure 19. Owning a system and the use of it during a trip is very close to each other. One can see that the navigation systems are the most used system in-car. The deviation of both navigation systems with or without live updates are fairly evenly spread. The second most used system is the radio, were can be seen that owning such a system does not indicate that it is always used for traffic information during a trip. Currently the still evolving smartphone apps are owned by a decent amount of respondents, but way less used during a trip compared to the other in-car system. The total amount of systems owned and used is higher than 231 this due the fact that one respondent can own multiple system. Sometimes there is a lower amount of people that own a certain system compared to the usage of it, this can be because the respondent does not own a certain system did borrow it from someone else.

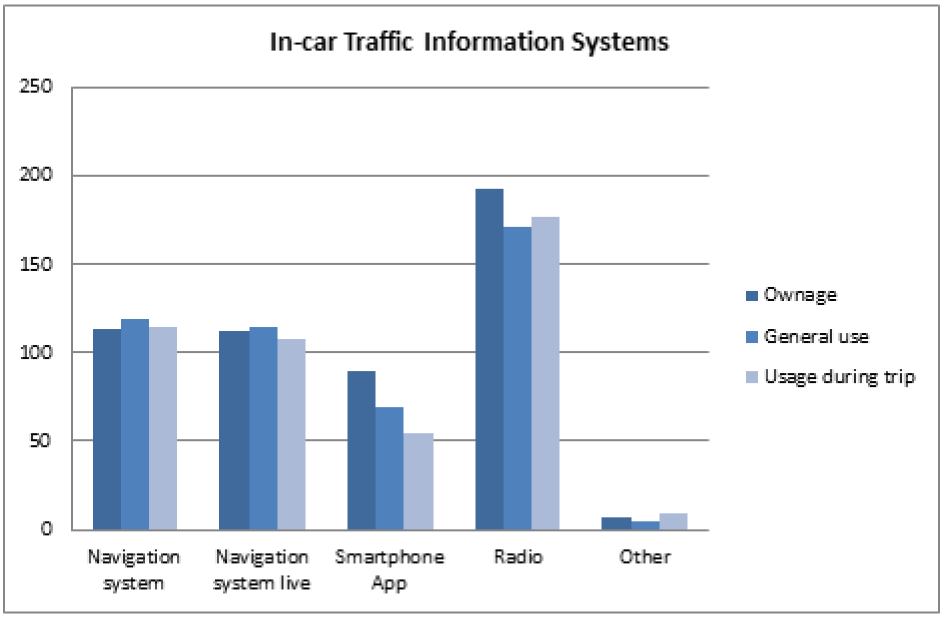


Figure 19 In-car traffic information systems owned, general use, and usage during trips

One of the important causes why respondents would deviate from their original route by their own perception are accidents (44.8%), followed by roadworks (25%), daily traffic jam (21.6%) and other reason (8.6%). If the route deviation reason is set out against the age, it gives the same ratio in the results. One can see that there is a difference between the genders on route deviation causes. Table 11 shows the chi-square test and *LL* for the cross tabulation of Gender and Route Deviation Reasoning, which is found to be significant. What can be seen in figure 20 is that the male have a strong dominant deviation reason which is when and accident is occurred. The female respondents are more evenly spread over the different kind of possible reasons for route deviation causes.

Table 11 Chi-Square Test for the Crosstab: Route Deviation Reasoning * Gender

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8,741[a]	3	,033
N of Valid Cases	231		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 5,02.

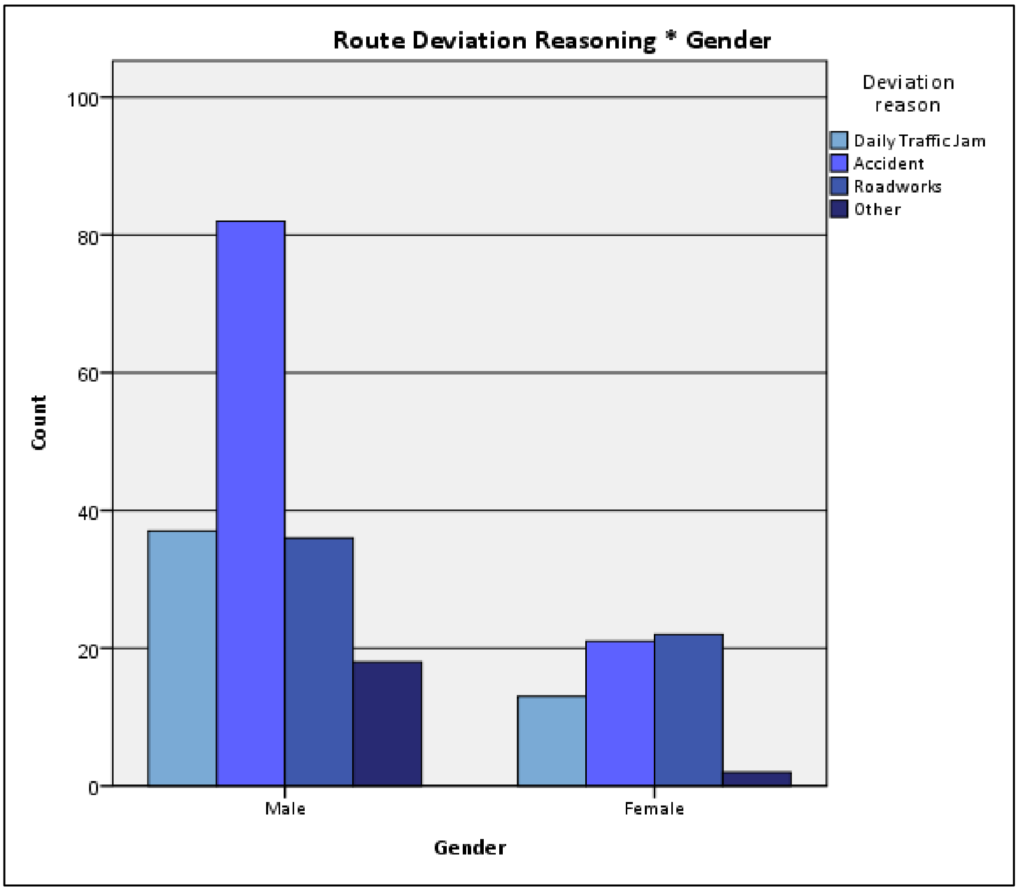


Figure 20 Cross tabulation Route Deviation Reasoning * Gender

Percentage wise between each gender the males have a distribution of; Daily traffic jam (21.4%), Accident (47.4%) and Roadworks (20.8%), where the accident rate is the most dominant. Female road users of the sample have percentage wise more evenly spread under the causes; Daily traffic jam (22.4%), Accident (36.4%) and Roadworks (37.9%). These results will be compared with the MNL model results in paragraph 5.4.2.

5.4.2 Multinomial logit model results

This paragraph shows the final MNL models. Nlogit 5 (Greene, 2000) is used to estimate the MNL models and to find the characteristics that influence the probability of a certain route choice. Firstly the performance of the actual model is tested to validate the usefulness of the optimal model. After the validation of the performance, the optimal model results are analyzed. This is also done for some additional group specific models. The additional models which consist of comparisons between different groups of respondents based on personal characteristics only give the R-square as to show how well the data fits that specific model.

Model Goodness of fit

To test if the model is decent enough the log likelihood ratio is determined as show in equation 5.9. The likelihood ratio statistic gives the opportunity to measure the performance of the attributes on the model with the use of the collected choice data. The log likelihood ratio test is done to compare the null model with constant only model, and the most optimal model. The null model is the model with all the attributes set to zero with the data divided 50/50 and the constant only model include only a constant representing the one choice alternative. Finally the optimal model has the variables added providing more context to the model and giving the most optimal log likelihood.

Table 12 shows the model's log likelihood and log likelihood ratio compared to the chi-square. The chi-square score can be found in a standard chi-square table with the use of the degrees of freedom difference compared to the null model generated from the Nlogit models. The log likelihood ratio is higher than the minimum score at 21 degrees of freedom at a 90% confidence interval in the chi-square table indicating a significant improvement. Both the constant only model and the optimal model are significantly better than the null model.

Table 12 Log likelihood ratio comparison with the chi-square

	Null model	*Constant only model*	*Optimal model*
Log likelihood	-1441.05299	-1375.0703	-1107.30691
Degrees of freedom	0	1	21
Chi-square (90% interval, p=0.1)	-	2.706	29.615
Log likelihood ratio	-	131.97	667.49

The R-square of the models is calculated with the use of equation 5.10. The R-square is often used in discrete models and indicate how well the model fits to the data. Nlogit gives an R-square which is calculated with the constant only model compared to the optimal model which is shown in table 13. However, to find a more optimal R-square the null model can be compared to the optimal model with the earlier given equation. Values given between 0.2 and 0.4 indicate a good model fit[9]. Compared to the null model the R-square gives a good fit. Compared to the constant only model the R-square is under the range of 0.2 to 0.4 and indicating a not so good fit, but the value is just slightly under the 0.2 limit. This does not matter since the R-square compared to the Null model already indicates a good fit.

Table 13 R-square comparison

	Compared to the Constant only model	*Compared to the Null model*
(Psuedo) R-square	0.1947	0.2316
Adjusted R-square	0.1865	-

Model results and interpretation

The generated MNL models can be interpreted with the results given by the estimates β. The β-estimate indicates the importance of a certain attribute level. The higher the β-estimate the higher the contribution is towards the utility. The first two levels of each attribute are provided with the β-estimate (or first level in two level attributes) generated by the model in Nlogit. The last level can be calculated by hand using the effect coding explained earlier as shown in paragraph 5.3.3. This is the sum of the given β-estimate per level multiplied by -1. The total sum of all the attribute levels β-estimates combined is zero again.

Table 14 shows all the attributes of the optimal model that has a significant effect on the route choice. The attribute is taken in consideration when at least one of the levels is significant. The attributes that are not listed in table 14 did not give a statistical significant effect in the confidence range of 90%. The β-estimate can also be called the part-worth utility.

All the route specific attributes that were taken in consideration in the model are found to be statistical significant. The non-significant attributes in the confidence range of 90% for the optimal model are Distance, Navigation and Radio. Appendix VI shows the model results and goodness of fit results generated directly from Nlogit.

[9] The model gets better if the value gets closer to 1. But values between 0.2 and 0.4 already indicate a good fit.

Table 14 Significant attributes from the MNL most optimal model

Attributes			Attribute level	Part-worth utility	significance
A-route specific	***Delay time A-route***	1	0 minutes	1.04547	***
		2	4 minutes	0.1263	*
		3	8 minutes	-1.17177	
	Truck Traffic A-route	1	Low amount (5%)	-0.15979	**
		2	Normal amount (10%)	0.01559	
		3	High amount (15%)	0.1442	
N-route specific	***Delay time N-route***	1	0 minutes	0.73715	***
		2	3 minutes	0.11691	
		3	6 minutes	-0.85406	
	Exit lanes N-route	1	2 Exit lanes	0.16159	**
		2	3 Exit lanes	0.17068	**
		3	4 Exit lanes	-0.33227	
	Section Start Time	1	Morning peak hours 6:00-10:00	0.254	***
		2	Non-peak hours	-0.10967	
		3	Evening peak hours 15:00-19:00u	-0.14433	
	Delay Cause	1	Daily Traffic Jam	0.17217	**
		2	Roadworks	-0.11999	
		3	Accidents	-0.05218	
	Bypass usage	1	Monthly use	0.12783	
		2	Weekly use	-0.33301	***
		3	Daily use	0.20518	
	Weather Circumstances	1	Clear vision	0.1322	**
		2	Unclear vision	-0.1322	
	DRIP	1	Active	-0.28906	***
		2	Inactive	0.28906	
	Constant			0.73625	***
***1% **5% *10% significance					

The part-worth utility in Table 14 can be visualized to give a clear overview. All the significant attributes are visualized and presented in the next three figures, separating the A-route, N-route, and non-route specific attributes.

Figure 22 shows the delay time and truck traffic attributes related to the choice specific A-route. Both attributes have a linear effect. The delay time has a higher part-worth utility than the truck traffic attribute which indicates that the delay time has a higher contribution towards the utility. As the delay time increases the utility score of the A-route is dropping which is expected. If an increase in delay time occurs then the car drivers are more likely to divert from the given route, as also found by Gan et al. (2013) and Wardman et al. (1997). When the percentage of truck traffic of all the road traffic at the A-route increases the drivers are more willing to choose the A-route. The cause of this behavior could be due to the flow of traffic that the truck drivers cause or the creation of awareness of the fastest route for the regional traffic, which truck drivers often take according to Arentze et al. (2012). It could also be due to the chosen visualization of the attribute truck traffic. However, the effect of an increased amount of truck traffic and a linear positive effect on the attractively of the A-route were not expected.

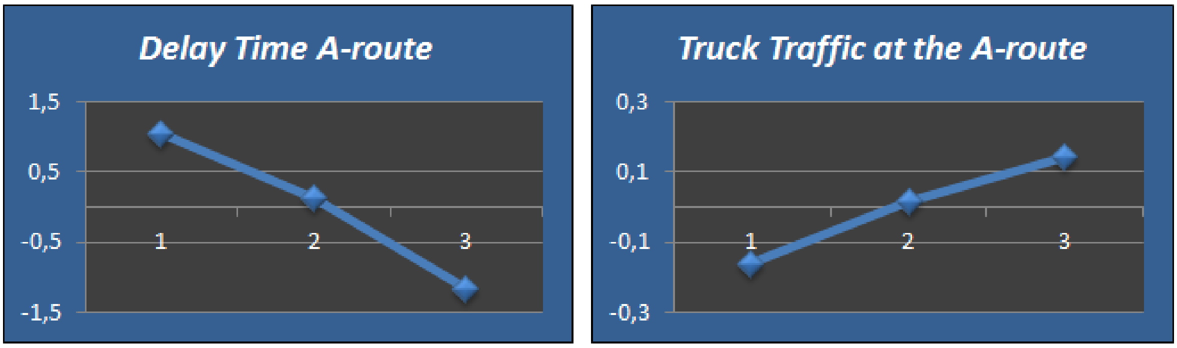


Figure 21 A-route specific attributes visualization

Figure 23 displays the N-route specific attributes which are the delay times at the N-route and the number of exit lanes at the N-route. The delay time on the N-route has a linear effect which shows that the increase of the delay time lowers the utility score for the N-route, which is expected. The attribute number of exit lanes at the N-route is not linear, a linear effect was however expected. There is a slight increase when going from attribute level one, which indicates two exit lanes, towards attribute level two indicating three exit lanes. There is a huge drop in the part-worth utility when there are four exit lanes at the N-route. Because of this drop and the minor difference between the first and second attribute level the behavior of this attribute can be seen as expected.

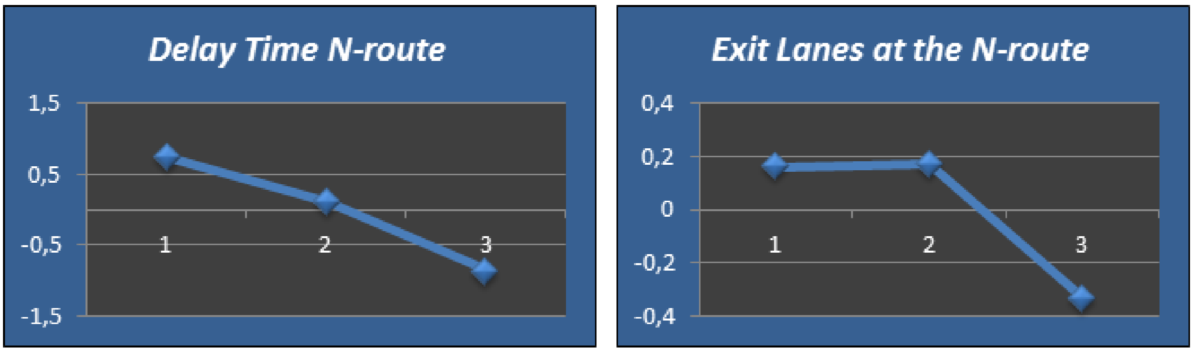


Figure 22 N-route specific attributes visualization

Figure 24 shows the non-route specific attributes. The *section start time* attribute has a linear effect on the choice probability. In the morning peak hours there is a higher contribution to the utility of the A-route than during the non-peak hours and evening peak hours. The difference between the morning and evening peak hours was not expected but can be explained due to the fact that the morning road users are often, commuting towards work as Bonsall & Joint (1991) and Gan et al. (2013) indicated. Commuters prefer the expressway more and often show more habitual behavior than the other road users. In the evening rush hour the commuters are often in another state of mind because the trip is now towards home.

The *cause of delay* in previous read literature was often significant, also in this SP research. The daily traffic jam has a positive effect on the utility towards the A-route, were as an accident and roadwork (slightly more) have a negative effect on the contribution of utility to the A-route compared with the N-route. Lee et al. (2004) found with their research towards route diversion and VMS that the attribute cause of delay the roadworks and accidents also had a positive effect on route diversion, in other words a negative effect on staying at the suggested regional route. Route diversion is also the case here since the respondents are told that they are transit traffic.

The attribute *bypass usage* is not completely as expected; where the monthly and daily drivers give a higher importance towards the A-route. The weekly drivers give a lower importance towards choosing the A-route. This effect is not expected but can be justified by the fact that the attribute level weekly is the only one out of the three that is statistical significant.

The *weather circumstances* indicate that with clear weather the respondents have a higher utility towards the A-route and they have a lower utility with unclear weather towards the A-route. This can be explained by the combination of sight and driving speed.

Lastly, the attribute of a *DRIP* either being active or inactive shows that when the DRIP is active a negative utility contribution is found and when inactive a positive utility contribution towards the A-route is found. This is understandable because the DRIP during the research always showed information containing either a delay in time and/or a delay cause on the DRIP. The DRIP shows the respondents information over the current traffic conditions at the different routes.

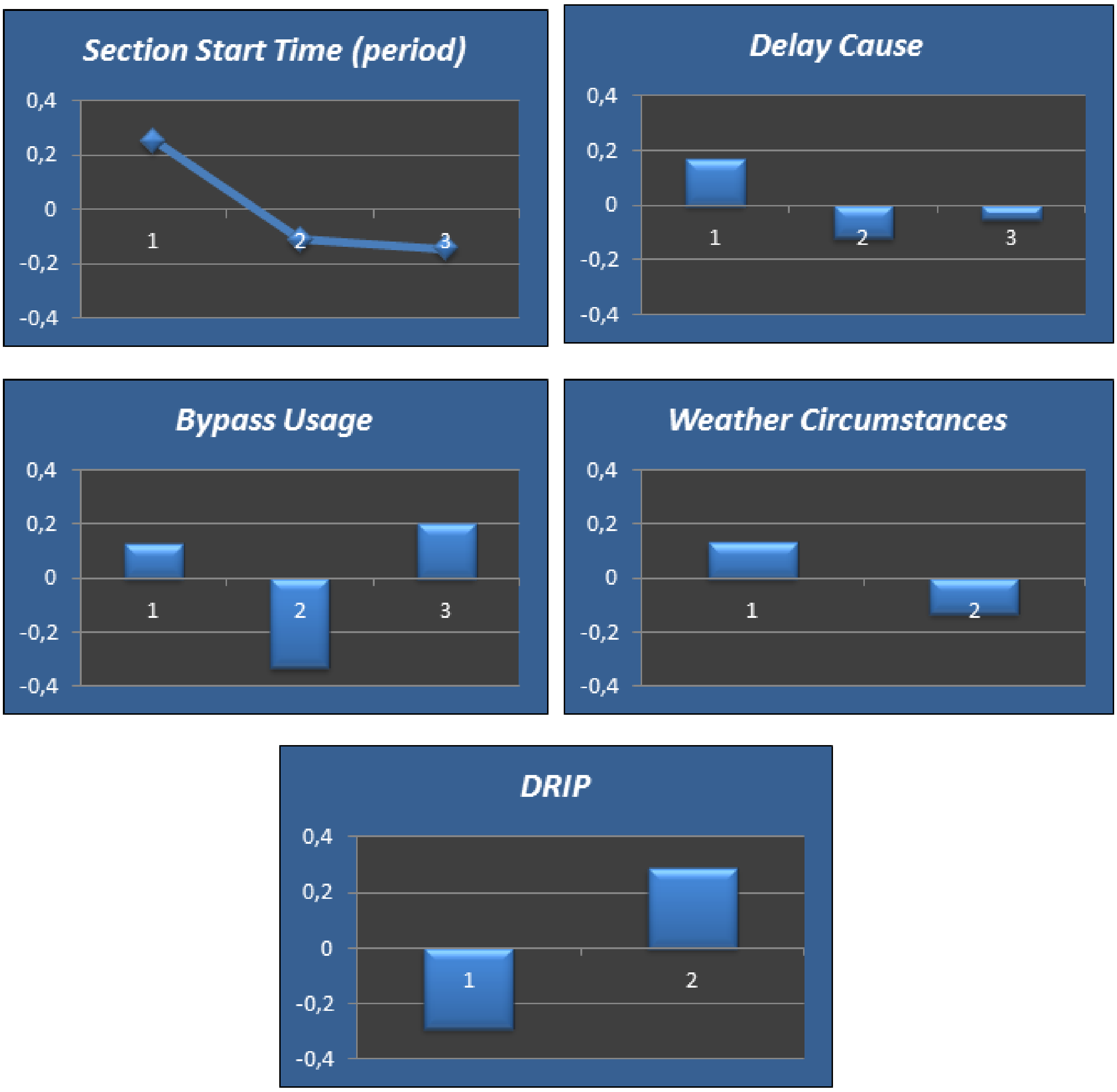


Figure 23 Visualization non-route specific attributes

Now that is know how the attributes act on their own, it is of interest to see the level of importance between the different significant attributes. This is also known as the relative importance where all the attributes have a different impact on the route choice. Figure 25 shows the impact of all significant attributes. Calculating the relative importance is done by measuring the absolute difference between the highest and lowest attribute level for each attribute separately. The range of each attribute is then divided by the total sum of all the attribute ranges resulting in a relative important in percentages (Marchau, Wiethoff, Penttinen, & Molin, 2001).

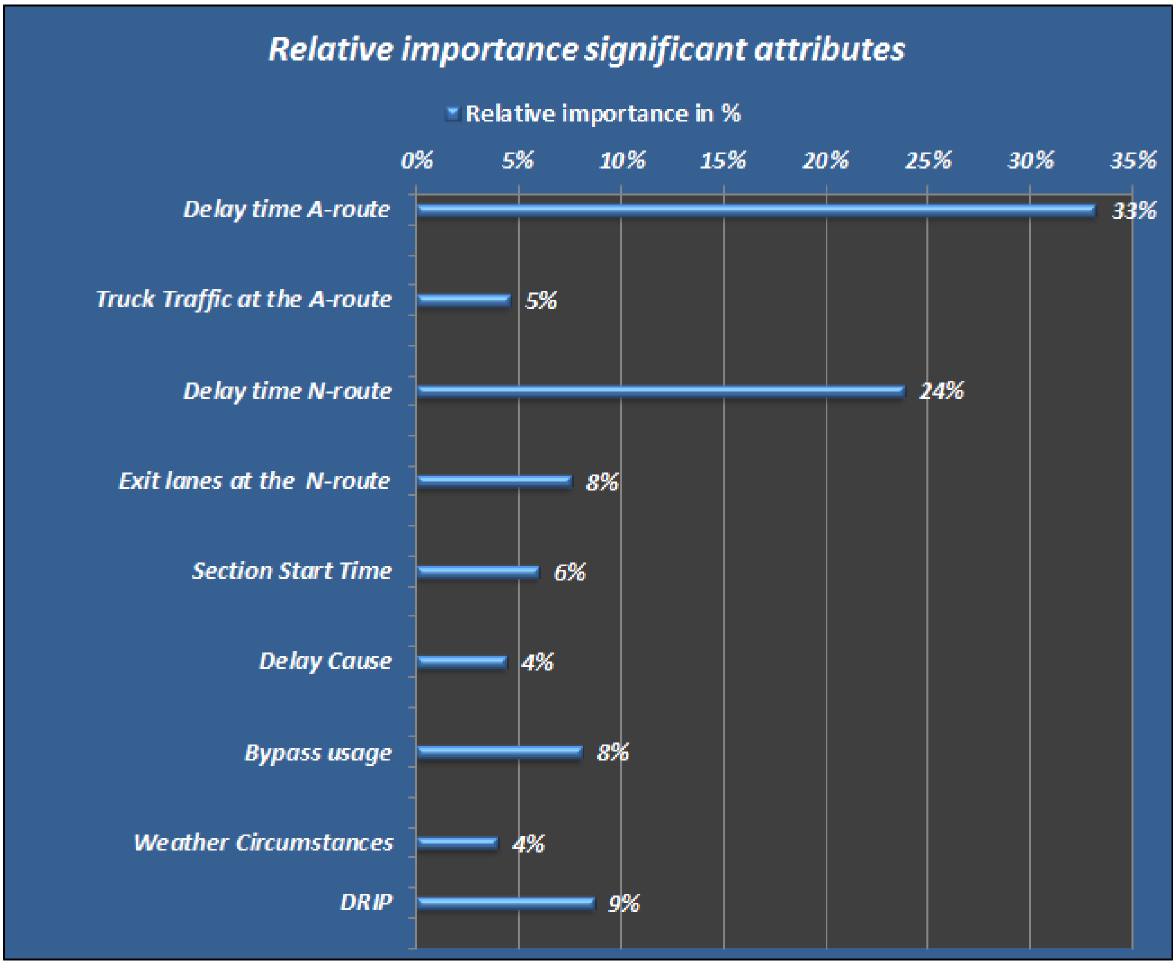


Figure 24 Relative importance for the significant attributes in the optimal model

The delay time of the A-route has the highest impact on car drivers' the route choice in unbundled road situation. This indicates that delays of certain extend at the A-route is important for the drivers to base their route choice on. The delay time of the N-route is the second most important attributes road users take in consideration whiles choosing a route. This is obvious because the road user will choose the A-route if the delay time that is shown on the A-route still results into a faster travel time than the delay time on the N-route combined with the normal travel times. The DRIP is at the third place of relative importance, hence that the DRIP shows the delay times for each route. All the other attributes are relatively close on the level of relative importance to each other.

Additional models with different group samples

The following models are also evaluated with the personal characteristic of the respondent taken into consideration. Taking these characteristics into consideration gives a view on the different groups of the sample used during the research. The r-square and adjusted r-square based on the constant only model are given for each model to indicate the goodness of fit. Only the significant attributes are shown in the next tables, the remaining results of the models can be found in Appendix VII.

The first model is based on the different *gender* groups; *male* and *female*. Many studies have been done towards comparing the risk behavior and accident response between male and female drivers. But almost none of these studies specifically address the route choice behavior between men and women. The model in table 15 shows some of these differences. In this research the proportion of males compared to females is way higher. Which might give deviant results. Still the model indicates that there are significant differences between the two genders at least for some attributes. All the results from the model can be seen in table 15. The results show that route specific attributes except from delay time have no significant influence on the female respondents for the route choice behavior. The cause of delay has no significant effect on the female respondents compared to the male respondents, which has an interaction with the results found in the descriptive analysis in figure 16. All the traffic information media have a statistical significance level of 10% for the female drivers. Females tend to follow instruction more than male, and obey to the traffic regulations and rules more on trip (Laapotti, Keskinen & Rajalin, 2003). This could be why in this research the navigation and radio system are significant for the female road users and not for the male road users in this research.

Table 16 show the model that is created for two different age groups consisting of drivers from 18 till 49 years old and 50 years and older. The number of respondents in each group is evenly spread among the model, which give representative results. The attributes that were not significant were radio and navigation systems. The route specific attributes except for delay times are not significant for the age group 18 till 49 years old. It seems that the respondents belonging to the age group 18 till 49 years old are more leaning towards causes, usage and circumstances such as weather while interpreting their route choice. Whereas the 50 years and older respondent focus more on the surrounding traffic and distance of the specific route choice segment.

Table 15 Model with Gender interaction

Gender		Male		Female	
Attributes	Level	Part-worth utility	significance	Part-worth utility	significance
Delay time A-route	1	1.01899	***	1.16118	***
	2	0.18794	**	-0.0184	
	3	-1.20693		-1.1428	
Truck Traffic at the A-route	1	-0.26523	***	0.12544	
	2	-0.01882		0.11712	
	3	0.28405		-0.2426	
Delay time N-route	1	0.82657	***	0.5303	***
	2	0.04486		0.37855	**
	3	-0.87143		-0.9089	
Exit lanes at the N-route	1	0.2283	**	-0.0149	
	2	0.18342	**	0.15868	
	3	-0.41172		-0.1437	
Section Start Time	1	0.25854	***	0.25774	*
	2	-0.17215	*	0.07618	
	3	-0.08639		-0.3339	
Delay Cause	1	0.17191	*	0.13586	
	2	-0.1739	**	0.08909	
	3	0.00199		-0.225	
Segment Distance	1	-0.14865		0.01307	
	2	0.15698	*	-0.0308	
	3	-0.00833		0.01769	
Bypass usage	1	0.16988	*	0.02556	
	2	-0.35086	***	-0.3062	*
	3	0.18098		0.28065	
Weather Circumstances	1	0.07357		0.29239	**
	2	-0.07357		-0.2924	
DRIP	1	-0.22979	***	-0.4902	***
	2	0.22979		0.49021	
Navigation	1	0.08596		-0.2346	*
	2	-0.08596		0.23455	
Radio	1	-0.00296		-0.2144	*
	2	0.00296		0.2144	
Constant		0.7221	***	0.82235	***
R-square		0.2106		0.1990	
R-square adjusted		0.1998		0.1654	
Estimation based on N		1557		522	
***1% **5% *10% significance					

Table 16 Model with Age interaction

Age		18 till 49 years old		50 years and older	
Attributes	Level	Part-worth utility	significance	Part-worth utility	significance
Delay time A-route	1	0.99978	***	1.14064	***
	2	0.21656	*	0.03259	
	3	-1.21634		-1.17323	
Truck Traffic at the A-route	1	-0.11034		-0.21111	**
	2	-0.05524		0.09082	
	3	0.16558		0.12029	
Delay time N-route	1	0.75557	***	0.75244	***
	2	0.16538		0.0625	
	3	-0.92095		-0.81494	
Exit lanes at the N-route	1	0.05296		0.28446	**
	2	0.07754		0.253	**
	3	-0.1305		-0.53746	
Section Start Time	1	0.29899	***	0.20455	*
	2	-0.08189		-0.1679	
	3	-0.2171		-0.03665	
Delay Cause	1	0.23472	**	0.10137	
	2	-0.258	**	0.01906	
	3	0.02328		-0.12043	
Segment Distance	1	0.00919		-0.24248	**
	2	0.04884		0.19752	*
	3	-0.05803		0.04496	
Bypass usage	1	0.01371		0.21889	*
	2	-0.39522	***	-0.26386	**
	3	0.38151		0.04497	
Weather Circumstances	1	0.16904	**	0.11007	
	2	-0.16904		-0.11007	
DRIP	1	-0.31215	***	-0.27953	***
	2	0.31215		0.27953	
Constant		0.79642	***	0.68597	***
R-square		0.2036		0.2028	
R-square adjusted		0.1873		0.1863	
Estimation based on N		1044		1035	
***1% **5% *10% significance					

The last evaluated model in table 17 is an interaction with the driving experience in years. The driving experience is divided into two separate groups consisting of 19 years or less and the group of 20 or more year of driving experience. This model has many similarities with the age model given in table 16 since the drivers with less driving experience are often younger people. However, the weather circumstances in this model are now significant in a range of 90% confidence interval for the 20 years or more experience drivers compared to the 50 years and older age group where this is not the case. The model on its own has a decent enough fit for the first category of driving experience. Literature showed that driving road users with more driving experience were more stimulated to follow traffic information that is presented. This can be seen in this model as well. With the increase of route deviation from the regional route when a delay of a certain extend is show on the DRIP.

Table 17 Model with Driving Experience interaction

Driving Experience		*19 years or less*		*20 years or more*	
Attributes	***Level***	***Part-worth utility***	***significance***	***Part-worth utility***	***significance***
Delay time A-route	1	1.09266	***	1.03296	***
	2	0.19794		0.08291	
	3	-1.2906		-1.11587	
Truck Traffic at the A-route	1	-0.13136		-0.18172	*
	2	0.03833		0.006	
	3	0.09303		0.17572	
Delay time N-route	1	0.8015	***	0.71423	***
	2	0.16017		0.09407	
	3	-0.96167		-0.8083	
Exit lanes at the N-route	1	0.03729		0.22912	**
	2	0.14698		0.18043	*
	3	-0.18427		-0.40955	
Section Start Time	1	0.36537	***	0.1922	**
	2	-0.1215		-0.10379	
	3	-0.24387		-0.08841	
Delay Cause	1	0.20322		0.14998	
	2	-0.27915	**	-0.03006	
	3	0.07593		-0.11992	
Bypass usage	1	0.08272		0.13596	
	2	-0.39633	***	-0.29252	***
	3	0.31361		0.15656	
Weather Circumstances	1	0.1528		0.11919	*
	2	-0.1528		-0.11919	
DRIP	1	-0.29199	***	-0.29414	***
	2	0.29199		0.29414	
Constant		0.83085	***	0.68059	***
R-square		0.2221		0.1857	
R-square adjusted		0.2007		0.1723	
Estimation based on N		783		1296	
***1% **5% *10% significance					

Simulation example

With the estimation results certain implications can be made. The estimation results can be used to generate the probabilities of the choices in different situations. In this section an example is given based on the road situation of the bypass in Eindhoven. The probabilities of the road users choosing the A2 or N2 based on the optimal model and gender specific model.

The simulation focuses on a road user who wants to travel from ‘s-Hertogenbosch towards Postel, just over the border in Belgium. The road user takes the A2-route towards the A67, which goes over the bypass in Eindhoven. The length of this segment is ten kilometers and has four exit lanes on this segment. There is a low amount of truck traffic and a four minute delay with a roadworks as cause at the regional traffic route. There are four exits and no further delay time on the local traffic route. The travel period is in the morning rush hour. The road user is doing this trip monthly. It is assumed that the weather is clear. The DRIP is active at this time period and the road user has traffic information available on the radio. Figure 26 visualizes the route of the road user.

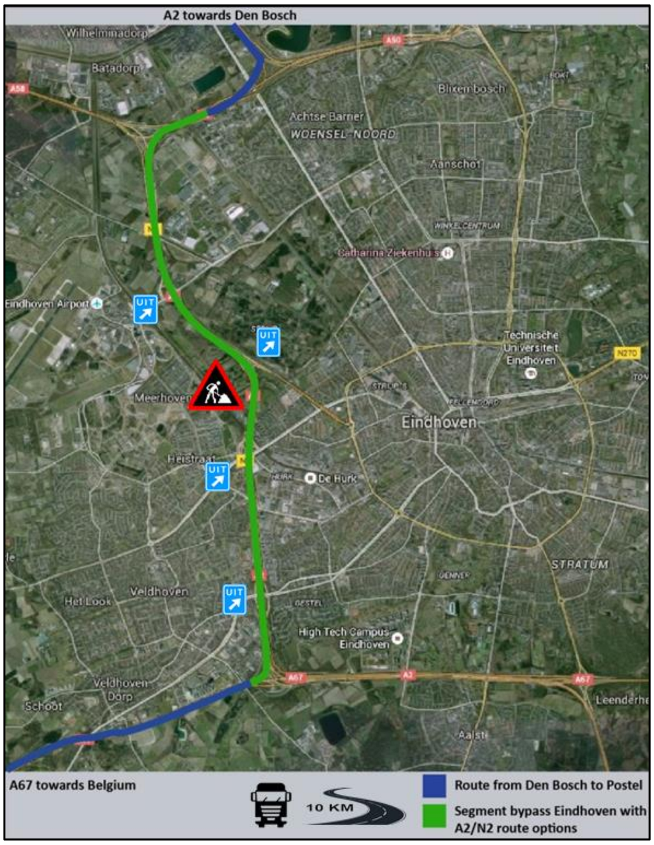


Figure 25 Scenario bypass segment Eindhoven (source: maps.google.nl)

The results of the simulation are shown in table 18. The optimal model is used with all the traffic information media active and the DRIP either inactive or active as shown table 19. Another example is given for the gender specific model in table 20. Appendix VIII gives the coding of the scenario and the complete calculation of each table.

Given the situation as described in the text, the road users will choose the regional traffic road with a probability of 55% and the local traffic road with a probability of 45%.

Table 18 Scenario Simulation Optimal Model

Scenario simulation: Optimal Model Scenario with DRIP active, Navigation inactive, and Radio active			
Alternative	*Utility*	*Exponent*	*Probability*
Regional traffic road (A)	0.5997	1.8216	54.9%
Local traffic road (N)	0.4049	1.4991	45.1%
		3.3207	

Given the simulation attribute levels of the situation described in the text, one can switch around with the activation of the different information systems. Ones all the systems are active and the DRIP is inactive the probabilities change and an increase of the probability of choosing the regional traffic road is measured (table 19). With all the systems active the probabilities almost do not change. Compared to the scenario simulation where the navigation is inactive. This was already expected because the navigation system has no significant impact on the route choice, therefore a low utility value.

Table 19 Optimal model with DRIP inactive and active

Optimal Model Scenario with DRIP inactive, Navigation active, and Radio active			
Alternative	*Utility*	*Exponent*	*Probability*
Regional traffic road (A)	1.1720	3,2285	68.3%
Local traffic road (N)	0.4049	1,4991	31.7%
		4.7277	
Scenario with DRIP active, Navigation active, and Radio active			
Alternative	*Utility*	*Exponent*	*Probability*
Regional traffic road (A)	0.5997	1.8112	54.7%
Local traffic road (N)	0.4049	1.4991	45.3%
		3.3207	

The DRIP either being active or inactive is also applied on the different gender specific models resulting into the probabilities of choosing the included routes (table 20). One can see that the probabilities differ a few percent between the female (65.3%) and male (70.7%)

road users when the DRIP is inactive. When the DRIP is active with the other systems the female (41.4%) road users are more reluctant to choose the regional traffic road. The male road users roughly have a probability change of 10%.

Table 20 Gender Specific Model Comparison DRIP active and inactive

Female Driver Scenario with DRIP inactive, Navigation active, and Radio active			
Alternative	***Utility***	***Exponent***	***Probability***
Regional traffic road (A)	1.0199	2.7729	65.3%
Local traffic road (N)	0.3866	1.4719	34.7%
		4.2448	
Female Driver Scenario with DRIP active, Navigation active, and Radio active			
Alternative	***Utility***	***Exponent***	***Probability***
Regional traffic road (A)	0.0395	1.0402	41.4%
Local traffic road (N)	0.3866	1.4719	58.6%
		2.5121	
Male Driver Scenario with DRIP inactive, Navigation active, and Radio active			
Alternative	***Utility***	***Exponent***	***Probability***
Regional traffic road (A)	1.2955	3.6529	70.7%
Local traffic road (N)	0.4149	1.5141	29.3%
		5.1671	
Male Driver Scenario with DRIP active, Navigation active, and Radio active			
Alternative	***Utility***	***Exponent***	***Probability***
Regional traffic road (A)	0.8359	2.3069	60.4%
Local traffic road (N)	0.4149	1.5142	39.6%
		3.8212	

To apply other policy measures on the situation, the exit lanes can be altered or the distance of a segment can be changed for instance. There are many possibilities to see how and when road users choose for certain routes. Based on these finding policies can be made.

5.5 Conclusion

Which and what effects do traffic information media have in different circumstances?

Which context and road related attributes influence the route choice of car drivers at highways with the use of different traffic information systems?

The research that is done with the use of the gathering method stated preference addresses the car drivers' route choice decisions at unbundled highways and the influence of travel information presented while driving. The data collected for this research was done with the use of an online questionnaire, which was distributed under a random sample of Dutch highway users. The gathered data was filtered and resulted in a total of 231 usable questionnaires. It was aimed to reach respondents with an age of minimum 18 years old and owning a driver's license B. The respondents that participated in the questionnaire were representative for the Dutch population with an average age of 46. The only setback of the gathered data was the proportional difference between the male and female respondents.

A MNL model was used to gain insight into the route choice and influential attributes towards the choice of a route with different traffic information media. The optimal MNL model was significantly better compared to the null-model, accordingly to the log-likelihood ratio. The R-square gave a decent fit of the model compared to the null-model. In the optimal model and the other generated models the *delay times* for each route were one of the most reoccurring significant attribute alongside the *DRIP*. The delay time as discussed several times in the literature study were expected to be influential on the route choice behavior. The DRIP either being active or inactive was also significant but less expected based of previous research. The DRIP being active and showing delay information had a positive effect on route choice towards local roads. Being inactive showed that many road users stayed on their transit route which is in the Netherlands often an A-road. The radio and navigation systems which are appreciated and used by many respondents had no significant effect on the route choice. This came as a surprise since the literature review showed that respondents had a positive attitude towards the personalized traffic and route information presented. There was only a significant impact of the two in-car systems for the female road users. When the traffic information systems were active compared to inactive gave a slight negative effect on the utility score of the A-route compared to the N-route for regional traffic. The negative effect was caused because information of a delay was always given when traffic information systems were active. Which concludes that all the traffic information systems add additional value towards route deviation for female drivers. With the use of the different models the last sub-question is answered.

The differences between the genders, age groups, and the driving experience gave some new insight towards the route choice for regional traffic with travel information presented while driving for both road side and in-car traffic information.

The decisions made by the car drivers are differently for several characteristics such as gender, age, and driving experience. In general the car drivers base their route choice on the shown travel information along the route based on the DRIP and the presented delay times of the route alternatives. Car drivers make their choices based on their own perception of the circumstances. Taking in mind the route specific attributes such as the truck traffic and the extra stress related driving tasks provided by exit lanes on local roads. For the non-route specific attributes, the car drivers mainly base their choice on the time of day (peak-hours) or how often they use a certain road segment, the familiarity. Circumstances such as weather and delay cause were found to be significant but had a lower impact on the actual route choice.

6. CONCLUSION

This chapter presents the conclusions that are drawn from the literature study and the research conducted. It combines the conclusions of each chapter with the relevance of this research at different levels. Starting with the societal relevance and followed by the scientific relevance. After the relevance is given a discussion towards the research is done which is finished with suggestions and recommendations for further studies.

6.1 Societal relevance

The research that is done during this graduation thesis contributes to a better understanding of the route choice behavior of car drivers given a regional and local route alternative with the use of road-side and in-car traffic information systems. The focus of this study is to find which attributes influence the route choice behavior on unbundled highways while driving, and the influence of the medium that provides the traffic information. This research is done because new traffic information systems are evolving rapidly and the already existing systems might get outdated or even obsolete. It is needed to get an understanding of how car drivers act and use the received traffic information provided by the different information systems. Knowing how the road users act towards the different systems can benefit the traffic flow by the right use of such systems. Also lot of traffic jams and other delays can be dealt with by providing the optimal guidance to the road user. This research especially gives a beneficial factor towards road segments with regional and local road situations.

Measurements that can be implemented are: decreasing the number of road exits lanes to increase the usage of the local road by the regional traffic. More exit lanes cause more stress related driving situation due to the weaving traffic. Decreasing the exit lanes will increase the usage of the local route. Influencing truck traffic to switch from the regional road to the local road can stimulates the regional traffic to follow the truck drivers and move towards the local road. This suggestion is made based on the part-worth utility of truck traffic at the regional route. Presenting the information during certain traffic rush hours can influence the traffic distribution, especially presenting the information during morning peak-hours. Keeping the DRIP sign with travel and possible delay times active give a beneficial effect on controlling the traffic streams, since many people still follow the information provided by the DRIPS. Another possible suggestion based on a none controllable factor; weather circumstances with the levels 'clear' and 'unclear' weather can be given. Unclear weather stimulates car drivers to switch from the regional road to the local roads, which have a lower speed limit (during this SP experiment). The results of this research show the importance of different attributes that contribute to the route choice and the behavior towards different information systems on trip. It is not only shown which attributes influence the choice, but also till what extend the attributes influence the choice. It shows that although the DRIP signs are one of the older systems, it is still appreciated and used by the car drivers for route choices, within the boundaries of this research.

6.2 Scientific relevance

Much research is done on the matter of different traffic information systems such as the VMS, navigation systems, and radio systems. All those different studies did focus on the aspect of which information should be shown and what information influences the route choice behavior the most. Combining these different information systems was not yet done, especially not with the still evolving navigation system providing live traffic information. With this research, it was possible to find the interaction between the different systems and if the presented information was followed by road users. It was also done to find if certain traffic information systems would become obsolete, especially the DRIP in this case. Additional road specific attributes were added which were not yet investigated such as the truck traffic (at the A-route) and the exit lanes (at the N-route). These attributes gave new insights in the matter of route choice. Were the increase of truck traffic at the A-route showed an increased utility towards the regional route. And the increase of exit lanes at the N-route showed a decrease in utility towards the local route for transit traffic, because of the extra driving tasks involved. Another difference is that not only regular highway users are asked to take part of this survey but the Dutch population in general. This is done to create a broad image of the perception of the research problem. The broader perception is gained because non-regular users of the highways have a different perception on route choice than regular highway users.

6.3 Discussion

This section consists of the discussion of certain weaknesses and improvements for the research. During the research all attributes were selected carefully, however not all attributes were found to be significant. A bigger respondents group can change this, or perhaps a more gender distributed respondents group. Which brings us to the following weakness, which was the male and female respondents ratio, Resulting in a research that could not be compared to the Dutch population in general. However, it is a fact that male road users drive more annual kilometers at the highways than female road users (FHWA, 1999). So the distribution for this research subject specifically is not that bad and should be compared with highway road users data instead of the general Dutch population data. The gender model showed that there were some significant differences among the male and female road users.

Setting up the survey was a difficult part during this study, especially the choice experiment. A risk of SP is that situations may not seem realistic enough to the respondents. Therefore, the design decisions were made very carefully to give the respondents the feeling of actual driving the car at a highway situation. The attributes that were selected had to be designed with caution. Trying to visualize the attributes was difficult, it was important to match the visualization of the attributes with known and realistic depictions. Therefore, traffic signs and images were used for the attributes when possible.

Truck traffic, one of the choice specific attributes for the A-route gave not the expected result as described in paragraph 5.4.2. This could have several reasons, one of them could be the visualization. Now there are small truck traffic icons used to show the amount of truck traffic at the A-route, this perhaps does not cover the feeling of a real-life situation with truck traffic at the highway. Adding a 'real' truck in the in-car visualization could have caused different reactions towards the truck traffic attribute. Another reason could also be the design of the situations. Because, the third attribute level of truck traffic was used in a few scenarios with low delay times at the A-route and vice versa. High amount of truck traffic at the A-route and high delay time on the N-route. Because the delay time was perceived more important than the truck traffic, the respondents preferred the A-route with low delay time but often with a high percentage of truck traffic.

The visualization of the traffic information systems were based on real products that are currently available on the market. The DRIP was designed fairly quickly, because it had to be a copy of the current roadside 'bermDRIPs' at unbundled highway situations. The other traffic information systems were more difficult to design. Especially the navigation system, since there are many different layouts used by the manufacturers of these systems. What I learned from designing the navigation system display was that it had to show clear and personal based traffic information. One needs to be very careful while adding text in a SP visualization, this should be short and understandable. However, sometimes long text sentences needed to be added, for instance at the radio system, which normally is verbal sound only. Adding sound fragments was considered but not feasible, due to the fact that the respondents tasks increase (having sound boxes, correct sound volume, and not missing the soundtrack that is played) and create an extra barrier in completing the survey.

Before the survey went online a pilot-survey was spread to test if the situations were clearly described and visualized. Most of the respondents could understand the situation visualization and description, but said that there was a lot of information shown. This due the complexity of the situation bound attributes and the visualization. However, all the shown attributes were needed to keep the situation as realistic as possible. Lowering the information overload as much as possible was done by adding additional graphical icons.

Aside from the chosen traffic information media the smartphone application was not taken in consideration. However, the booming nature of these so called 'apps' are still interesting to research in combination with other traffic information media. Not choosing the smartphone apps was due the fact of the redundant information shown in combination with navigation systems. This would have decreased the reality of certain situations in the SP experiment. Using the apps aside from its navigational purposes was not an option. Mainly because there would be different kind of layouts and presentations needed, making the choice experiment even more complex than it already was. Since apps can have different kind of options such as; showing traffic jams, speed controls, alternative routes by speech or maps, and even more.

6.4 Suggestions & recommendations

This research provides additional information to policy makers and governmental parties to keep investing in the current DRIP systems. The DRIPS are still heavily used by the current road users, even in combination with the new upcoming traffic information systems. Providing traffic information with different systems and road designs needs to be taken in consideration by policy makers to form strategical policies and tactical approaches to address the current problems of congestions.

The gained information can also be useful for private companies involved in designing navigation systems and (possible) smartphone application. Comparing the given information by the DRIPs with their own more personalized information. And figure out why the information is more followed by the DRIPs than in-car systems for unbundled highway situations. Also see which traffic information attribute can provide a beneficial effect on their specific systems, information deployment and presentation.

Recommendations for further research on evaluating different traffic information systems are given. An important traffic information system is the current heavily evolving smartphone applications. One could do additional research towards the display and usefulness of different kind of smartphone application whiles driving in later studies. Focusing more on route specific attributes can also give more insight in the road design and the influence of route choices by car drivers. Designing different information systems and doing research towards specific preferences of displaying the information adds also more value to this research. Because, certain layouts are chosen in the stated preference experiment for the navigation system and radio system presentation. The design options are always good to review, especially when they contain specific attribute levels. An example of different visualizations were the weather condition, which had the level 'clear' and 'unclear vision.' Clear weather was shown as a sunny day and unclear vision as a rainy situation. Changing these weather visualization could trigger other route choice outcomes.

Making more interaction between the respondent's characteristics could give more interesting insights to the analysis results. The situations used during this research are based on hard unbundling, doing the same for soft unbundling could give other insights which are interesting to review.

The AII tests explained in paragraph 5.3.2 were not conducted during this research. Which could be a good addition to check the attributes and choice alternatives. However, the model was not too complex that this was necessary. If AII was to be found another Nested logit model could have been applied.

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Appendix I - Correlation between the variables

Correlations

		Segment Arrive Time	Delay Cause	Segment distance	Bypass Usage (familiarity)	Truck Traffic A-route	Exit lanes N-route	Delay Time A-route	Delay time N-route	Weather Circumstances	Dynamic Route Information Panel	Navigation System	Radio
Segment Arrive Time	Pearson Correlation	1	,000	,000	,000	,000	,000	,000	,000	,000	,092	,000	,000
	Sig. (2-tailed)		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	,647	1,000	1,000
	N	27	27	27	27	27	27	27	27	27	27	27	27
Delay Cause	Pearson Correlation	,000	1	,000	,000	,000	,000	,000	,000	,000	-,092	,000	,000
	Sig. (2-tailed)	1,000		1,000	1,000	1,000	1,000	1,000	1,000	1,000	,647	1,000	1,000
	N	27	27	27	27	27	27	27	27	27	27	27	27
Segment distance	Pearson Correlation	,000	,000	1	,000	,000	,000	,000	,000	,000	-,092	,000	,092
	Sig. (2-tailed)	1,000	1,000		1,000	1,000	1,000	1,000	1,000	1,000	,647	1,000	,647
	N	27	27	27	27	27	27	27	27	27	27	27	27
Bypass Usage (familiarity)	Pearson Correlation	,000	,000	,000	1	,000	,000	,000	,000	,000	-,092	,000	,000
	Sig. (2-tailed)	1,000	1,000	1,000		1,000	1,000	1,000	1,000	1,000	,647	1,000	1,000
	N	27	27	27	27	27	27	27	27	27	27	27	27
Truck Traffic A-route	Pearson Correlation	,000	,000	,000	,000	1	,000	,000	,000	-,032	-,149	,000	,043
	Sig. (2-tailed)	1,000	1,000	1,000	1,000		1,000	1,000	1,000	,876	,458	1,000	,833
	N	27	27	27	27	27	27	27	27	27	27	27	27
Exit lanes N-route	Pearson Correlation	,000	,000	,000	,000	,000	1	,000	,000	,000	-,092	,000	-,092
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000		1,000	1,000	1,000	,647	1,000	,647
	N	27	27	27	27	27	27	27	27	27	27	27	27
Delay Time A-route	Pearson Correlation	,000	,000	,000	,000	,000	,000	1	,000	,000	,092	,000	,092
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	1,000		1,000	1,000	,647	1,000	,647
	N	27	27	27	27	27	27	27	27	27	27	27	27
Delay time N-route	Pearson Correlation	,000	,000	,000	,000	,000	,000	,000	1	,000	,092	,000	-,092
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	1,000	1,000		1,000	,647	1,000	,647
	N	27	27	27	27	27	27	27	27	27	27	27	27
Weather Circumstances	Pearson Correlation	,000	,000	,000	,000	-,032	,000	,000	,000	1	,169	,000	,017
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	,876	1,000	1,000	1,000		,401	1,000	,933
	N	27	27	27	27	27	27	27	27	27	27	27	27
Dynamic Route Information Panel	Pearson Correlation	,092	-,092	-,092	-,092	-,149	-,092	,092	,092	,169	1	-,107	-,074
	Sig. (2-tailed)	,647	,647	,647	,647	,458	,647	,647	,647	,401		,597	,714
	N	27	27	27	27	27	27	27	27	27	27	27	27
Navigation System	Pearson Correlation	,000	,000	,000	,000	,000	,000	,000	,000	,000	-,107	1	-,107
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	,597		,597
	N	27	27	27	27	27	27	27	27	27	27	27	27
Radio	Pearson Correlation	,000	,000	,092	,000	,043	-,092	,092	-,092	,017	-,074	-,107	1
	Sig. (2-tailed)	1,000	1,000	,647	1,000	,833	,647	,647	,647	,933	,714	,597	
	N	27	27	27	27	27	27	27	27	27	27	27	27

Appendix II - Scenarios with corresponding attribute levels and choice sets

Scenarios with attributes levels and final sets

Scenarios	Section Start Time	Delay Cause	Segment Distance	Bypass usage (familiarity)	Truck Traffic A-route	Exit lanes N-route	Delay time A-route	Delay time N-route	Weather Circumstances	Dynamic Route Information Panel	Navigation system	Radio traffic information
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	2	3	1	3	3	3	2	1	1	2
3	1	1	3	2	2	2	2	2	2	2	2	1
4	1	2	1	3	3	3	2	2	2	1	1	1
5	1	2	2	2	2	2	1	1	1	1	1	1
6	1	2	3	1	1	1	3	3	1	2	2	1
7	1	3	1	2	2	2	3	3	1	1	1	2
8	1	3	2	1	1	1	2	2	2	2	1	2
9	1	3	3	3	3	3	1	1	1	1	2	2
10	2	1	1	3	2	1	3	2	1	1	2	1
11	2	1	2	2	1	3	2	1	1	2	1	1
12	2	1	3	1	3	2	1	3	2	1	1	1
13	2	2	1	2	1	3	1	3	2	2	2	1
14	2	2	2	1	3	2	3	2	1	2	1	2
15	2	2	3	3	2	1	2	1	1	1	1	2
16	2	3	1	1	1	2	2	1	2	1	2	2
17	2	3	2	3	2	1	1	3	2	2	1	1
18	2	3	3	2	1	3	3	2	1	1	1	1
19	3	1	1	2	3	1	2	3	1	2	1	2
20	3	1	2	1	2	3	1	2	1	1	2	2
21	3	1	3	3	1	2	3	1	2	2	1	2
22	3	2	1	1	2	3	3	1	2	2	1	1
23	3	2	2	3	1	2	2	3	1	1	2	1
24	3	2	3	2	1	1	1	2	2	1	1	2
25	3	3	1	3	1	2	1	2	1	2	1	1
26	3	3	2	2	3	1	3	1	2	1	2	1
27	3	3	3	1	2	3	2	3	1	1	1	1

Set Number	Scenarios (in survey set order)								
1	2	11	14	4	13	5	20	22	27
2	23	7	18	15	17	12	21	3	25
3	1	6	8	24	10	26	19	9	16

Appendix III - Visualization information media

Figure 26 DRIP visualization

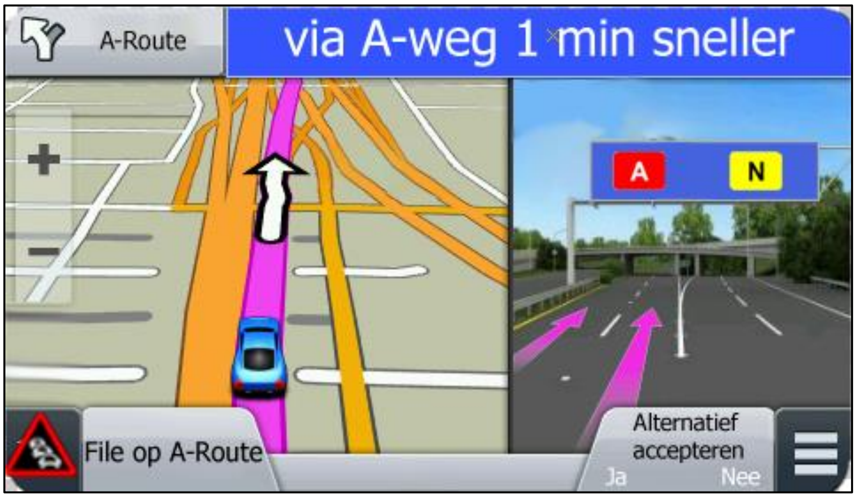

Figure 27 Navigation System visualization

Figure 28 Radio visualization

Appendix IV Online questionnaire

Not all the visualizations of the scenarios are displayed due to fact of the extensive length of this appendix otherwise.

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Routekeuze gedrag op snelwegen

Welkom!

Bedankt voor uw interesse in mijn enquête!

Deze enquête gaat over de invloed van het verstrekken van verkeersinformatie via verschillende bronnen tijdens het rijden over de snelweg en het daaruit voortkomende routekeuzegedrag.

Deze enquête is onderverdeeld in drie verschillende delen en beslaat ongeveer **10 minuten** van uw tijd.
Deel 1 bestaat uit een aantal vragen over uw rijgedrag en de bekendheid met verschillende verkeersinformatie bronnen.
Deel 2 bestaat uit een aantal scenario's waarin verschillende situaties aan bod komen waarin uw routekeuze gevraagd.
Deel 3 bestaat uit een aantal persoonsgebonden vragen.

Veel plezier bij het invullen van de enquête en alvast bedankt voor uw medewerking!
In de bovenste roze balk kunt u uw voortgang van de enquête zien.

Pieter van Oirschot
Masterstudent Construction, Management and Engineering
Technische Universiteit Eindhoven

Al uw gegevens worden anoniem verwerkt. En deze worden op geen enkel wijze gebruikt voor commerciële doeleinden of verspreid aan derden.

Begin Enquête

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Hoe vaak maakt u gebruik van de snelweg?

- nooit
- minder dan 1 keer per maand
- 1-3 keer per maand
- 1 keer per week
- 2-3 keer per weer
- 3 keer of meer per week

Bent u vaak op de weg voor uw werk?

- Nooit
- Soms
- Regelmatig
- Vaak
- Altijd

Hoeveel kilometer legt u gemiddeld per jaar af in de auto?

- Minder dan 5000 kilometers
- 5.000 - 9.999 kilometers
- 10.000 - 19.999 kilometers
- 20.000 - 29.999 kilometers
- 30.000 kilometers of meer
- Weet ik niet

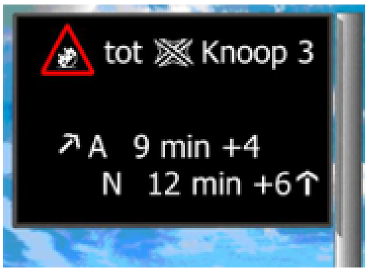
Vorige Volgende

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Hoe vaak ziet u onderstaande 'Dynamische Route Informatie Panelen' (DRIPs) tijdens het rijden?

- Nooit
- Soms
- Regelmatig
- Vaak
- Altijd



Hoe vaak leest u de gepresenteerde informatie op dergelijke DRIPs?

- Nooit
- Soms
- Regelmatig
- Vaak
- Altijd

Vindt u de gepresenteerde informatie op de DRIPs geloofwaardig?

- Ongeloofwaardig
- Redelijk ongeloofwaardig
- Neutraal
- Redelijk geloofwaardig
- Geloofwaardig

Hoe vaak wijzigt u uw route op basis van de informatie op een DRIP?

- Nooit
- Soms
- Regelmatig
- Vaak
- Altijd

Vorige | Volgende

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Welke van de volgende verkeersinformatie bronnen gebruikt u wel eens voor, tijdens of na uw trip?

Meerdere antwoorden zijn mogelijk

- ☐ Navigatiesysteem zonder live verkeersinformatie
- ☐ Navigatiesysteem met live verkeersinformatie
- ☐ Radio
- ☐ Dynamisch Route Informatie Paneel
- ☐ Verkeersinformatie App (op smartphone of tablet)
- ☐ Internet websites (bijv. Google Maps, 9292OV, vanAnaarBeter.nl etc.)
- ☐ Teletekst
- ☐ Anders namelijk:

Anders Namelijk

Welke van de volgende apparaten bezit u momenteel?

Meerdere antwoorden zijn mogelijk

- ☐ Navigatiesysteem zonder live verkeersinformatie
- ☐ Navigatiesysteem met live verkeersinformatie
- ☐ Verkeersinformatie App (op smartphone of tablet)
- ☐ Radio
- ☐ Anders namelijk:

Welke van de volgende apparaten gebruikt u tijdens het rijden?

Meerdere antwoorden zijn mogelijk

- ☐ Navigatiesysteem zonder live verkeersinformatie
- ☐ Navigatiesysteem met live verkeersinformatie
- ☐ Verkeersinformatie App (op smartphone of tablet)
- ☐ Radio
- ☐ Anders namelijk:

Vorige | Volgende

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Geef aan hoeveel waarde de onderstaande begrippen hebben voor u.

	Zeer weinig	Weinig	Gemiddeld	Veel	Zeer veel
Een vaste reistijd voor de route	○	○	○	○	○
De kortste route	○	○	○	○	○
De snelste route	○	○	○	○	○
De route al vaker afgelegd hebben	○	○	○	○	○

Wat is voor u de belangrijkste reden om van uw route af te wijken?

- ○ Dagelijkse file
- ○ Ongeluk
- ○ Wegwerkzaamheden
- ○ Anders namelijk:

Vorige

Volgende

Technische Universiteit Eindhoven University of Technology

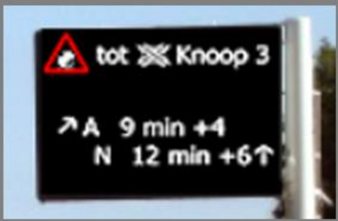
Routekeuze gedrag op snelwegen

Deel 2 - Scenario's

U bent nu aangekomen in **Deel 2** van deze enquête.

In dit deel krijgt u een aantal scenario's voorgeschoteld met daarin verschillende situaties. Het is de bedoeling om met de gepresenteerde informatie een keuze te maken tussen twee verschillende routes over een deel van de snelweg (segment).

Tijdens elk scenario worden de onderstaande verkeersinformatie bronnen getoond, deze worden visueel weergegeven in een in-car afbeelding.

Dynamisch Route Informatie Paneel	*Navigatiesysteem*	*Radiobericht*
		
Op de DRIP wordt de **oorzaak** van de vertraging getoond en tot welk **knooppunt** deze vertraging is. Tevens wordt de **reistijd van het segment** samen met de **vertragingstijd** getoond. Voor de A-weg is het rechts aanhouden en de N-weg is het rechtdoor, de wegen lopen wel parallel aan elkaar.	Op het navigatiesysteem wordt linksonder de **oorzaak** en de **locatie** van de vertraging weergegeven. Bovenin het scherm wordt de **snelste route** aangegeven. Het systeem heeft live verkeersinformatie updates.	Het radiobericht geeft de **oorzaak**van de file, de **locatie** van de file en de bijbehorende **vertragingstijd** per route.

Vorige | Volgende

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Deel 2 - Scenario's

U kunt kiezen uit twee routes: ***A-Route*** en ***N-Route***. Deze routes hebben verschillende kenmerken zoals hieronder is weergegeven! De kenmerken voor de ***A-Route*** en ***N-Route*** zijn in elk scenario hetzelfde.

Het gaat om het **type van de weg**, de **maximum snelheid**, het **aantal rijstroken** en als **extra informatie** de mogelijkheid om een afrit te gebruiken. Deze worden bij elk scenario herhaald.

De A- en N-route hebben de volgende vaste kenmerken.

	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of Plaatselijk verkeer
Maximum Snelheid	120	80
Aantal Rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Vorige | Volgende

Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Deel 2 - Scenario's

Per scenario worden steeds wisselende kenmerkwaarden getoond. De kenmerken en de waarden staan hieronder nader beschreven. Links ziet u de omschrijving van de kenmerken. In het rechter deel van de tabel ziet u de waarden die de kenmerken kunnen aannemen.

Tijdstip van de keuzemogelijkheid: dit is de begintijd waarop u op de ringweg komt en de keuze moet maken tussen de **A-route** of **N-route**	Ochtendspits (6:00-10:00), Buiten spitstijden, Avondspits (15:00-19:00)
Het gebruik van de ringweg, dit komt overeen met hoe vaak u deze ringweg gebruikt	Dagelijks, Wekelijks of Maandelijks
De oorzaak van de vertraging, bestaande uit drie verschillende mogelijkheden	Dagelijkse file: Wegwerkzaamheden: Ongeval:
De lengte tot het volgende knooppunt, deze is 5, 10 of 15 kilometer	5 KM 10 KM 15 KM
Vrachtverkeer op de A-route, 1 vrachtwagen staat voor weinig vrachtverkeer oplopend tot een maximum van 3 dat staat voor veel vrachtverkeer	
Het aantal afritten op de N-route wordt aangegeven met het "UIT" bord, tot een maximum van 4 afritten	UIT

Op de volgende pagina volgt eerst een voorbeeldvraag.

Vorige Volgende

TU/e Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Hieronder ziet u een voorbeeld-situatie waarin wij u vragen een keuze te maken tussen de **A-route** en de **N-route**.

	Hierin worden de **situatie gebonden kenmerken** weergegeven deze veranderen per scenario.		Hierin wordt de **visualisatie van de huidige situatie** weergegeven, met daarin alle actieve verkeersinformatie bronnen en de informatie die deze geven in de desbetreffende situatie.
	Hier worden de **A-route** en **N-route** beschreven. Deze zijn elk scenario hetzelfde. *In de onderste tabel kunt u uw routekeuze maken!*		

Beschrijving (deze is elk scenario hetzelfde)

U bevindt zich op een ringweg rond een stad. Er is een vertraging op deze ringweg, er zijn twee mogelijke routes waaruit gekozen kan worden. Deze routes zijn respectievelijk een A-weg of N-weg. U bent doorgaand verkeer en moet het hele traject afleggen van 5, 10 of 15 kilometer.

	Situatie gebonden kenmerken
Tijdstip van keuze mogelijkheid	Buiten spitstijden
Gebruik van de ringweg	Maandelijks
Oorzaak vertraging	
Knooppunt lengte	15 KM
Vrachtverkeer op A Route	
Afritten op N Route	UIT UIT UIT

	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of plaatselijk verkeer
Maximum Snelheid	120	80
Aantal rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Visualisatie Situatie

Selecteer uw route voorkeur op basis van de situatie		
Geef hier uw keuze	A - Route	N - Route

Er volgen nu nog 9 verschillende scenario's, neem uw tijd bij het beantwoorden van deze scenario's!

Vorige Volgende

TU/e Technische Universiteit Eindhoven University of Technology

Routekeuze gedrag op snelwegen

Deel 2 - Scenario 1 van 9

Beschrijving

U bevindt zich op een ringweg rond een stad. Er is een vertraging op deze ringweg, er zijn twee mogelijke routes waaruit gekozen kan worden. Deze routes zijn respectievelijk een A-weg of N-weg. U bent doorgaand verkeer en moet het hele traject afleggen van 5, 10 of 15 kilometer.

	Situatie gebonden kenmerken	
Tijdstip van keuze mogelijkheid	Avondspits (15:00-19:00)	
Gebruik van de ringweg	Dagelijks	
Oorzaak vertraging		
Knooppunt lengte	10 KM	
Vrachtverkeer op A Route		
Afritten op N Route	UIT UIT UIT	
	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of plaatselijk verkeer
Maximum Snelheid	120	80
Aantal rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Visualisatie Situatie

Selecteer uw route voorkeur op basis van de situatie		
Geef hier uw keuze	A - Route	N - Route

Vorige Volgende

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Routekeuze gedrag op snelwegen

Deel 2 - Scenario 2 van 9

Beschrijving

U bevindt zich op een ringweg rond een stad. Er is een vertraging op deze ringweg, er zijn twee mogelijke routes waaruit gekozen kan worden. Deze routes zijn respectievelijk een A-weg of N-weg. U bent doorgaand verkeer en moet het hele traject afleggen van 5, 10 of 15 kilometer.

	Situatie gebonden kenmerken	
Tijdstip van keuze mogelijkheid	Ochtendspits (6:00-10:00)	
Gebruik van de ringweg	Wekelijks	
Oorzaak vertraging		
Knooppunt lengte	5 KM	
Vrachtverkeer op A Route		
Afritten op N Route	UIT UIT UIT	
	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of plaatselijk verkeer
Maximum Snelheid	120	80
Aantal rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Visualisatie Situatie

Selecteer uw route voorkeur op basis van de situatie		
Geef hier uw keuze	A - Route	N - Route

Vorige Volgende

TU/e Technische Universiteit Eindhoven University of Technology Routekeuze gedrag op snelwegen

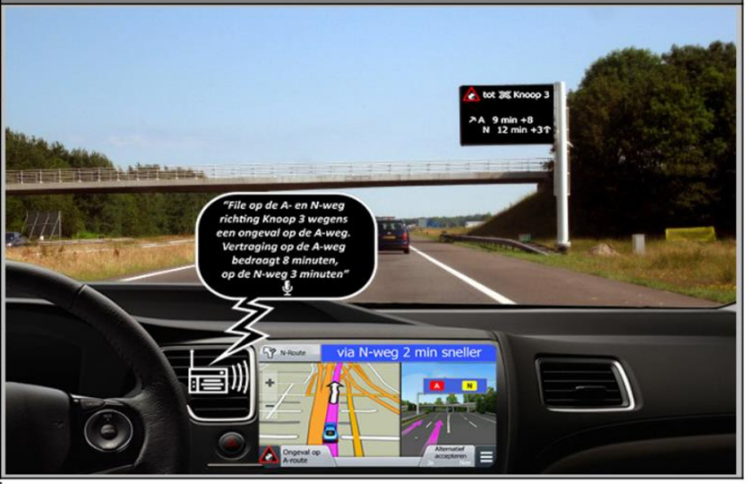
Deel 2 - Scenario 3 van 9

Beschrijving

U bevindt zich op een ringweg rond een stad. Er is een vertraging op deze ringweg, er zijn twee mogelijke routes waaruit gekozen kan worden. Deze routes zijn respectievelijk een A-weg of N-weg. U bent doorgaand verkeer en moet het hele traject afleggen van 5, 10 of 15 kilometer.

	Situatie gebonden kenmerken	
Tijdstip van keuze mogelijkheid	Buiten spitstijden	
Gebruik van de ringweg	Wekelijks	
Oorzaak vertraging		
Knooppunt lengte	15 KM	
Vrachtverkeer op A Route		
Afritten op N Route	UIT UIT UIT UIT	
	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of plaatselijk verkeer
Maximum Snelheid	120	80
Aantal rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Visualisatie Situatie



Selecteer uw route voorkeur op basis van de situatie		
Geef hier uw keuze	A - Route	N - Route

Vorige Volgende

TU/e Technische Universiteit Eindhoven University of Technology Routekeuze gedrag op snelwegen

Deel 2 - Scenario 6 van 9

Beschrijving

U bevindt zich op een ringweg rond een stad. Er is een vertraging op deze ringweg, er zijn twee mogelijke routes waaruit gekozen kan worden. Deze routes zijn respectievelijk een A-weg of N-weg. U bent doorgaand verkeer en moet het hele traject afleggen van 5, 10 of 15 kilometer.

	Situatie gebonden kenmerken	
Tijdstip van keuze mogelijkheid	Buiten spitstijden	
Gebruik van de ringweg	Maandelijks	
Oorzaak vertraging		
Knooppunt lengte	15 KM	
Vrachtverkeer op A Route		
Afritten op N Route	UIT UIT UIT	
	A - Route	N - Route
Type	Doorgaand verkeer	Doorgaand of plaatselijk verkeer
Maximum Snelheid	120	80
Aantal rijstroken	2 + vluchtstrook	2 + vluchtstrook
Extra Informatie	Geen afritten tot aan het volgende knooppunt	Tussendoor mogelijk de N-weg te verlaten via afritten

Visualisatie Situatie

Selecteer uw route voorkeur op basis van de situatie		
Geef hier uw keuze	A - Route	N - Route

Vorige Volgende

Technische Universiteit Eindhoven
University of Technology

Routekeuze gedrag op snelwegen

Deel 3 - Persoonlijke kenmerken

U bent aangekomen bij het laatste deel van deze enquête!

Dit gedeelte bestaat uit een aantal korte vragen over uw persoonsgebonden eigenschappen.

Vorige | Volgende

Technische Universiteit Eindhoven
University of Technology

Routekeuze gedrag op snelwegen

Wat is uw geslacht?

- Man
- Vrouw

Wat is uw leeftijd?

Wat is uw hoogst afgeronde opleidingsniveau?

Make a choice

Bent u in het bezit van een autorijbewijs (minimaal Rijbewijs B)?

- Ja
- Nee

Hoeveel jaar rijervaring heeft u?

Vorige | Volgende

Routekeuze gedrag op snelwegen

Heeft u naar aanleiding van deze enquête nog vragen, opmerkingen en/of suggesties?

Als u op de hoogte gehouden wilt worden van het verdere verloop van dit onderzoek, dan kunt u hieronder uw e-mailadres achterlaten.

Klik op 'Versturen' om de enquête af te ronden en te versturen!

Vorige Versturen

Routekeuze gedrag op snelwegen

Dit is het einde van deze enquête, hartelijk dank voor uw bijdrage aan dit onderzoek!

U kunt de enquête delen doormiddel van de onderstaande link, het delen van deze enquête zorgt voor een enorme bijdrage aan het resultaat van dit onderzoek.

https://Vragen1.ddss.nl/q/Routekeuze

Met vriendelijke groet,

Pieter van Oirschot
Masterstudent Construction, Management and Engineering
Technische Universiteit Eindhoven

Appendix V - Age and gender compared to CBS data

AGE compared to CBS results (2015 1st of January)

		Frequency	Valid Percent	CBS
Valid	20 years and younger	6	2,6%	22,7%
	20 till 40 years	78	33,8%	24,5%
	40 till 65 years	120	51,9%	35,1%
	65 years and older	27	11,7%	17,8%
	Total	231	100,0%	

GENDER compared to CBS results (2015 1st of January)

		Frequency	Valid Percent	CBS	
Valid	Male	173	74,9%	49,5%	
	Female	58	25,1%	50,5%	
	Total	231	100%	10000%	

Appendix VI - Constant only and optimal model Nlogit

Constant only model

```
|-> read ; Nobs   = 4158
    ; Nvar   = 26
    ; Names  = irsp,iset,ialt,jalt,choi,icon,
    Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2,
    Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,
    Weath,Drip,Navig,Radio
    ; Format = (2f6.0,24f4.0)
    ; File   = invoer1.dat$
|-> DISCRETECHOICE; Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon$
Normal exit:   4 iterations. Status=0, F=    1375.070

-----------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -1375.07031
Estimation based on N =   2079, K =   1
Inf.Cr.AIC  =   2752.1 AIC/N =    1.324
Model estimated: Jun 21, 2016, 11:05:01
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1375.0703  .0000-.0005
Response data are given as ind. choices
Number of obs.=  2079, skipped    0 obs
--------+--------------------------------------------------------------------
--
        |                  Standard            Prob.      95% Confidence
    CHOI|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
--
    ICON|     .51211***      .04531    11.30  .0000      .42330    .60091
--------+--------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

Optimal model

```
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    1107.307

----------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -1107.30691
Estimation based on N =   2079, K =  21
Inf.Cr.AIC  =   2256.6 AIC/N =    1.085
Model estimated: Jun 21, 2016, 11:05:09
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1375.0703  .1947 .1865
Response data are given as ind. choices
Number of obs.=  2079, skipped    0 obs
--------+-------------------------------------------------------------------


--
        |                Standard            Prob.      95% Confidence
    CHOI|  Coefficient     Error        z    |z|>Z*        Interval
--------+-------------------------------------------------------------------
--
    ICON|     .73625***     .06902    10.67  .0000      .60096    .87153
  TRUCK1|    -.15979**      .07520    -2.13  .0336     -.30718   -.01241
  TRUCK2|     .01559        .08217      .19  .8495     -.14547    .17665
   ATIM1|    1.04547***     .08806    11.87  .0000      .87288   1.21806
   ATIM2|     .12630*       .07576     1.67  .0955     -.02218    .27478
   EXIT1|     .16159**      .07812     2.07  .0386      .00847    .31471
   EXIT2|     .17068**      .07578     2.25  .0243      .02216    .31919
   NTIM1|     .73715***     .07612     9.68  .0000      .58795    .88634
   NTIM2|     .11691        .07560     1.55  .1220     -.03126    .26508
  1_PR11|     .25400***     .07409     3.43  .0006      .10878    .39922
  1_PR21|    -.10967        .08059    -1.36  .1736     -.26763    .04829
  1_CA11|     .17217**      .07784     2.21  .0270      .01961    .32472
  1_CA21|    -.11999        .07557    -1.59  .1123     -.26810    .02812
  1_DI11|    -.10243        .07722    -1.33  .1847     -.25378    .04892
  1_DI21|     .11537        .07884     1.46  .1434     -.03916    .26990
  1_US11|     .12783        .07946     1.61  .1077     -.02792    .28357
  1_US21|    -.33301***     .07665    -4.34  .0000     -.48324   -.18278
  1_WEA1|     .13220**      .05830     2.27  .0234      .01794    .24647
  1_DRI1|    -.28906***     .06149    -4.70  .0000     -.40958   -.16853
  1_NAV1|    -.00291        .06126     -.05  .9621     -.12298    .11716
  1_RAD1|    -.06189        .06027    -1.03  .3045     -.18002    .05624
--------+-------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Optimal model complete table

	Attributes		Attribute level	β	significance
A-route specific	***Delay time A-route***	1	0 minutes	1,04547	0***
		2	4 minutes	0,1263	0,0955*
		3	8 minutes	-1,17177	
	Truck Traffic A-route	1	Low amount (5%)	-0,15979	0,0336**
		2	Normal amount (10%)	0,01559	0,8495
		3	High amount (15%)	0,1442	
N-route specific	***Delay time N-route***	1	0 minutes	0,73715	0***
		2	3 minutes	0,11691	0,122
		3	6 minutes	-0,85406	
	Exit lanes N-route	1	2 Exit lanes	0,16159	0,0386**
		2	3 Exit lanes	0,17068	0,0243**
		3	4 Exit lanes	-0,33227	
	Section Start Time	1	Morning peak hours 6:00-10:00	0,254	0,0006***
		2	Non-peak hours	-0,10967	0,1736
		3	Evening peak hours 15:00-19:00u	-0,14433	
	Delay Cause	1	Daily Traffic Jam	0,17217	0,027**
		2	Roadworks	-0,11999	0,1123
		3	Accidents	-0,05218	
	Segment Distance	1	5 kilometer	-0,10243	0,1847
		2	10 kilometer	0,11537	0,1434
		3	15 kilometer	-0,01294	
	Bypass usage	1	Monthly use	0,12783	0,1077
		2	Weekly use	-0,33301	0***
		3	Daily use	0,20518	
	Weather Circumstances	1	Clear vision	0,1322	0,0234**
		2	Unclear vision	-0,1322	
	DRIP	1	Active	-0,28906	0***
		2	Inactive	0,28906	
	Navigation	1	Active	-0,00291	0,9621
		2	Inactive	0,00291	
	Radio	1	Active	-0,06189	0,3045
		2	Inactive	0,06189	

Appendix VII – Different sample group models

Gender: Male

```
|-> read ; Nobs   = 4158
    ; Nvar   = 29
    ; Names  = irsp,iset,ialt,jalt,choi,icon,
    Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2,
    Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,
    Weath,Drip,Navig,Radio,Gend,Iage,DREX
    ; File   = invoer2.dat$
|-> reject; Gend=2$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    814.7817
-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -814.78172
Estimation based on N =   1557, K =  21
Inf.Cr.AIC  =   1671.6 AIC/N =    1.074
Model estimated: Jun 21, 2016, 11:26:51
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1032.1378  .2106 .1998
Response data are given as ind. choices
Number of obs.=  1557, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
    CHOI|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
    ICON|     .72210***     .08011     9.01  .0000      .56508     .87912
  TRUCK1|    -.26523***     .08840    -3.00  .0027     -.43850    -.09196
  TRUCK2|    -.01882        .09692     -.19  .8460     -.20878     .17114
   ATIM1|    1.01899***     .10145    10.04  .0000      .82016    1.21782
   ATIM2|     .18794**      .08979     2.09  .0363      .01195     .36393
   EXIT1|     .22830**      .09157     2.49  .0127      .04883     .40777
   EXIT2|     .18342**      .08900     2.06  .0393      .00898     .35785
   NTIM1|     .82657***     .08918     9.27  .0000      .65178    1.00136
   NTIM2|     .04486        .08905      .50  .6144     -.12966     .21939
  1_PR11|     .25854***     .08798     2.94  .0033      .08609     .43098
  1_PR21|    -.17215*       .09431    -1.83  .0680     -.35700     .01270
  1_CA11|     .17191*       .09180     1.87  .0611     -.00802     .35184
  1_CA21|    -.17390**      .08853    -1.96  .0495     -.34741    -.00040
  1_DI11|    -.14865        .09114    -1.63  .1029     -.32728     .02997
  1_DI21|     .15698*       .09158     1.71  .0865     -.02251     .33648
  1_US11|     .16988*       .09517     1.78  .0743     -.01665     .35642
  1_US21|    -.35086***     .08936    -3.93  .0001     -.52600    -.17571
  1_WEA1|     .07357        .06846     1.07  .2825     -.06061     .20775
  1_DRI1|    -.22979***     .07143    -3.22  .0013     -.36979    -.08979
  1_NAV1|     .08596        .07219     1.19  .2337     -.05552     .22744
  1_RAD1|    -.00296        .07129     -.04  .9669     -.14269     .13677
--------+--------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Gender: Female

```
|-> SAMPLE ; All $
|-> reject; Gend=1$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    274.5982
```

```
-----------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -274.59824
Estimation based on N =    522, K =  21
Inf.Cr.AIC  =    591.2 AIC/N =    1.133
Model estimated: Jun 21, 2016, 11:27:13
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -342.8171  .1990 .1654
Response data are given as ind. choices
Number of obs.=   522, skipped    0 obs
```

CHOI	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
ICON	.82235***	.14636	5.62	.0000	.53550	1.10920
TRUCK1	.12544	.15598	.80	.4213	-.18027	.43115
TRUCK2	.11712	.16785	.70	.4853	-.21186	.44610
ATIM1	1.16182***	.19044	6.10	.0000	.78856	1.53508
ATIM2	-.01842	.15349	-.12	.9045	-.31926	.28242
EXIT1	-.01494	.16085	-.09	.9260	-.33019	.30032
EXIT2	.15868	.15465	1.03	.3049	-.14443	.46179
NTIM1	.53030***	.15742	3.37	.0008	.22175	.83884
NTIM2	.37855**	.15491	2.44	.0145	.07494	.68217
1_PR11	.25774*	.15011	1.72	.0860	-.03648	.55196
1_PR21	.07618	.16977	.45	.6536	-.25656	.40892
1_CA11	.13586	.15712	.86	.3872	-.17210	.44381
1_CA21	.08909	.16028	.56	.5783	-.22505	.40323
1_DI11	.01307	.15783	.08	.9340	-.29628	.32242
1_DI21	-.03076	.16631	-.18	.8533	-.35673	.29520
1_US11	.02556	.15693	.16	.8706	-.28202	.33315
1_US21	-.30621*	.15793	-1.94	.0525	-.61575	.00333
1_WEA1	.29239**	.11953	2.45	.0144	.05811	.52667
1_DRI1	-.49021***	.13289	-3.69	.0002	-.75067	-.22974
1_NAV1	-.23455*	.12662	-1.85	.0640	-.48273	.01363
1_RAD1	-.21440*	.12084	-1.77	.0760	-.45124	.02244

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Age: Age 50 years and older

```
|-> SAMPLE ; All $
|-> reject; Iage <3$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    550.0667
```

```
-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -550.06668
Estimation based on N =   1035, K =  21
Inf.Cr.AIC  =   1142.1 AIC/N =    1.104
Model estimated: Jun 21, 2016, 11:27:42
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -690.0303  .2028 .1863
Response data are given as ind. choices
Number of obs.=  1035, skipped    0 obs
```

CHOI	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
ICON	.68597***	.10104	6.79	.0000	.48794	.88400
TRUCK1	-.21111**	.10651	-1.98	.0475	-.41987	-.00235
TRUCK2	.09082	.11770	.77	.4403	-.13986	.32150
ATIM1	1.14064***	.12560	9.08	.0000	.89446	1.38682
ATIM2	.03259	.10750	.30	.7618	-.17810	.24328
EXIT1	.28446**	.11385	2.50	.0125	.06131	.50761
EXIT2	.25300**	.10759	2.35	.0187	.04212	.46388
NTIM1	.75244***	.11040	6.82	.0000	.53605	.96883
NTIM2	.06250	.10944	.57	.5679	-.15200	.27701
1_PR11	.20455*	.10625	1.93	.0542	-.00369	.41279
1_PR21	-.16790	.11453	-1.47	.1426	-.39238	.05657
1_CA11	.10137	.11164	.91	.3639	-.11745	.32019
1_CA21	.01906	.10798	.18	.8599	-.19257	.23068
1_DI11	-.24248**	.11025	-2.20	.0278	-.45856	-.02640
1_DI21	.19752*	.11209	1.76	.0780	-.02218	.41722
1_US11	.21889*	.11608	1.89	.0593	-.00861	.44640
1_US21	-.26386**	.10920	-2.42	.0157	-.47789	-.04983
1_WEA1	.11007	.08196	1.34	.1793	-.05056	.27070
1_DRI1	-.27953***	.08576	-3.26	.0011	-.44763	-.11144
1_NAV1	.00427	.09153	.05	.9628	-.17513	.18367
1_RAD1	-.07796	.08806	-.89	.3760	-.25055	.09464

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Age: Age 49 years and younger

```
|-> SAMPLE ; All $
|-> reject; Iage >2$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    545.1400

---------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -545.14002
Estimation based on N =   1044, K =  21
Inf.Cr.AIC  =   1132.3 AIC/N =    1.085
Model estimated: Jun 21, 2016, 11:28:03
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -684.5262  .2036 .1873
Response data are given as ind. choices
Number of obs.=  1044, skipped    0 obs
--------+------------------------------------------------------------------
--
```

CHOI	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
ICON	.79642***	.09831	8.10	.0000	.60374	.98910
TRUCK1	-.11034	.11022	-1.00	.3168	-.32637	.10568
TRUCK2	-.05524	.11976	-.46	.6446	-.28997	.17948
ATIM1	.99978***	.12933	7.73	.0000	.74630	1.25325
ATIM2	.21656*	.11063	1.96	.0503	-.00026	.43338
EXIT1	.05296	.11112	.48	.6336	-.16484	.27076
EXIT2	.07754	.11038	.70	.4824	-.13879	.29388
NTIM1	.75557***	.10898	6.93	.0000	.54197	.96916
NTIM2	.16538	.10879	1.52	.1285	-.04785	.37861
1_PR11	.29899***	.10615	2.82	.0049	.09093	.50705
1_PR21	-.08189	.11735	-.70	.4853	-.31189	.14811
1_CA11	.23472**	.11298	2.08	.0378	.01328	.45615
1_CA21	-.25800**	.10947	-2.36	.0184	-.47255	-.04345
1_DI11	.00919	.11281	.08	.9351	-.21192	.23029
1_DI21	.04884	.11385	.43	.6679	-.17431	.27199
1_US11	.01371	.11239	.12	.9029	-.20657	.23399
1_US21	-.39522***	.11160	-3.54	.0004	-.61396	-.17649
1_WEA1	.16904**	.08621	1.96	.0499	.00006	.33802
1_DRI1	-.31215***	.09129	-3.42	.0006	-.49107	-.13322
1_NAV1	.00261	.08507	.03	.9755	-.16412	.16935
1_RAD1	-.05878	.08576	-.69	.4931	-.22687	.10930

```
--------+------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Driving experience: 19 years and less

```
|-> SAMPLE ; All $
|-> reject; DREX >3$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    398.9337

-----------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -398.93371
Estimation based on N =    783, K =  21
Inf.Cr.AIC  =    839.9 AIC/N =    1.073
Model estimated: Jun 21, 2016, 11:29:28
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -512.8338  .2221 .2007
Response data are given as ind. choices
Number of obs.=   783, skipped    0 obs
--------+--------------------------------------------------------------------
--
        |                  Standard            Prob.      95% Confidence
    CHOI|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
--
    ICON|     .83085***      .11754     7.07  .0000      .60048   1.06121
  TRUCK1|    -.13136         .12862    -1.02  .3071     -.38346    .12074
  TRUCK2|     .03833         .14232      .27  .7876     -.24060    .31727
   ATIM1|    1.09266***      .15320     7.13  .0000      .79240   1.39292
   ATIM2|     .19794         .12912     1.53  .1253     -.05512    .45101
   EXIT1|     .03729         .13232      .28  .7781     -.22206    .29664
   EXIT2|     .14698         .12958     1.13  .2567     -.10699    .40094
   NTIM1|     .80150***      .12888     6.22  .0000      .54890   1.05411
   NTIM2|     .16017         .12822     1.25  .2116     -.09113    .41148
  1_PR11|     .36537***      .12516     2.92  .0035      .12007    .61067
  1_PR21|    -.12150         .13816     -.88  .3792     -.39228    .14928
  1_CA11|     .20322         .13297     1.53  .1264     -.05739    .46383
  1_CA21|    -.27915**       .12823    -2.18  .0295     -.53047   -.02783
  1_DI11|    -.08086         .13069     -.62  .5361     -.33700    .17529
  1_DI21|     .13468         .13545      .99  .3200     -.13079    .40015
  1_US11|     .08272         .13389      .62  .5367     -.17971    .34515
  1_US21|    -.39633***      .12977    -3.05  .0023     -.65067   -.14198
  1_WEA1|     .15280         .10159     1.50  .1326     -.04631    .35191
  1_DRI1|    -.29119***      .10653    -2.73  .0063     -.49997   -.08240
  1_NAV1|    -.03880         .10224     -.38  .7044     -.23919    .16160
  1_RAD1|    -.11349         .10191    -1.11  .2655     -.31324    .08626
--------+--------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
```

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Driving experience: 19 years and more

```
|-> SAMPLE ; All $
|-> reject; DREX <4$
|-> DISCRETECHOICE;Lhs = choi
    ; Choices = 1,2
    ; Rhs     = icon,Truck1,Truck2,Atim1,Atim2,Exit1,Exit2,Ntim1,Ntim2
    ; Rh2     = Pr1,Pr2,Ca1,Ca2,Di1,Di2,Us1,Us2,Weath,Drip,Navig,Radio$
Normal exit:   6 iterations. Status=0, F=    701.7723

-----------------------------------------------------------------------------
--
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -701.77235
Estimation based on N =   1296, K =  21
Inf.Cr.AIC  =   1445.5 AIC/N =    1.115
Model estimated: Jun 21, 2016, 11:29:54
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -861.8504  .1857 .1723
Response data are given as ind. choices
Number of obs.=  1296, skipped    0 obs
--------+--------------------------------------------------------------------
--
        |                  Standard            Prob.      95% Confidence
    CHOI|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
--
    ICON|     .68059***      .08632     7.88  .0000       .51140    .84978
  TRUCK1|    -.18172*        .09381    -1.94  .0527     -.36559    .00214
  TRUCK2|     .00600         .10184      .06  .9530     -.19360    .20560
   ATIM1|    1.03296***      .10883     9.49  .0000       .81966   1.24625
   ATIM2|     .08291         .09449      .88  .3802     -.10229    .26812
   EXIT1|     .22912**       .09830     2.33  .0198       .03646    .42177
   EXIT2|     .18043*        .09444     1.91  .0561     -.00466    .36552
   NTIM1|     .71423***      .09552     7.48  .0000       .52702    .90144
   NTIM2|     .09407         .09464      .99  .3202     -.09143    .27957
  1_PR11|     .19220**       .09291     2.07  .0386       .01010    .37429
  1_PR21|    -.10379         .10060    -1.03  .3022     -.30097    .09339
  1_CA11|     .14998         .09707     1.55  .1223     -.04027    .34023
  1_CA21|    -.03006         .09472     -.32  .7510     -.21571    .15559
  1_DI11|    -.12943         .09714    -1.33  .1827     -.31982    .06095
  1_DI21|     .11590         .09809     1.18  .2374     -.07637    .30816
  1_US11|     .13596         .09962     1.36  .1723     -.05929    .33122
  1_US21|    -.29252***      .09617    -3.04  .0024     -.48100   -.10404
  1_WEA1|     .11919*        .07222     1.65  .0989     -.02236    .26074
  1_DRI1|    -.29414***      .07633    -3.85  .0001     -.44374   -.14454
  1_NAV1|     .02516         .07737      .33  .7451     -.12649    .17680
  1_RAD1|    -.03127         .07545     -.41  .6786     -.17914    .11661
--------+--------------------------------------------------------------------
--
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
--
```

Truck = Truck Traffic, ATIM = delay time at the A-route, NTIM = delay time at the N-route, EXIT = Exit lanes at the N-route, 1_PR = Section start time, 1_CA = Delay Cause, 1_DI = Segment Distance, 1_US = Bypass Usage, 1_WEA = Weather Circumstance, 1_DRI = DRIP, 1_NAV = Navigation system with live updates, 1_RAD = Radio system

Appendix VIII Real scenario simulation

Simulation description:

The simulation consist of a road user that wants to travel from 's-Hertogenbosch towards Postel just over the border in Belgium. The road user takes the route over the A2 towards the A67, which goes over the bypass in Eindhoven. The length of this segment is ten kilometers and has four exit lanes. There is a low amount of truck traffic and a four minute delay with an roadwork as cause at the transit traffic route. There are four exits and no further delay time on the local traffic route. The travel period is in the morning rush hour over a segment of 10 kilometers. The road user is doing this trip monthly. Today the weather was unclear. The DRIP was active at this and the road user had traffic information available on the radio

	Alternative bound attributes																					
	const.	A-Truck		A-Delay		N-Exits		N-Delay		Period		Cause		Distance		Usage		Weather	Drip	Navigation	Radio
A	1	1	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	-1	1	-1	1
N	0	0	0	0	0	-1	-1	1	0	1	0	0	1	0	1	1	0	-1	1	-1	1

Optimal Model
Scenario with DRIP active, Navigation inactive, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,73625 + -0,15979 + 0,12630 + 0 + 0 |+ 0,254 + -0,11999 + 0,11537 + 0,12783 + -0,13220 + -0,28906 + 0.00291 + -0.06189</td><td>0,5997</td><td>1,8216</td><td>55%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,33227 + 0,73715 | + 0</td><td>0,4049</td><td>1,4991</td><td>45%</td></tr>
<tr><td></td><td></td><td></td><td>3,3207</td><td></td></tr>
</table>

Optimal Model
Scenario with DRIP inactive, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,73625 + -0,15979 + 0,12630 + 0 + 0 |+ 0,254 + -0,11999 + 0,11537 + 0,12783 + -0,13220 + 0,28906 + -0.00291 + -0.06189</td><td>1,1720</td><td>3,2285</td><td>68%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,33227 + 0,73715 | + 0</td><td>0,4049</td><td>1,4991</td><td>32%</td></tr>
<tr><td></td><td></td><td></td><td>4,7277</td><td></td></tr>
</table>

Optimal Model
Scenario with DRIP active, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,73625 + -0,15979 + 0,12630 + 0 + 0 |+ 0,254 + -0,11999 + 0,11537 + 0,12783 + -0,13220 + -0,28906 + -0.00291 + -0.06189</td><td>0,5940</td><td>1,8112</td><td>55%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,33227 + 0,73715 | + 0</td><td>0,4049</td><td>1,4991</td><td>45%</td></tr>
<tr><td></td><td></td><td></td><td>3,3103</td><td></td></tr>
</table>

Gender Model: Female Driver
Scenario with DRIP inactive, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,82235 + 0,12544 + -0,01842 + 0 + 0 |+ 0,25774 + 0,08909 + -0,03076 + 0,02556 + -0,29239 + 0,49021 + -0,23455 + -0,2144</td><td>1,0199</td><td>2,7729</td><td>65%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,14374 + 0,53030 | + 0</td><td>0,3866</td><td>1,4719</td><td>35%</td></tr>
<tr><td></td><td></td><td></td><td>4,2448</td><td></td></tr>
</table>

Gender Model: Female Driver
Scenario with DRIP active, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,82235 + 0,12544 + -0,01842 + 0 + 0 |+ 0,25774 + 0,08909 + -0,03076 + 0,02556 + -0,29239 + -0,49021 + -0,23455 + -0,2144</td><td>0,0395</td><td>1,0402</td><td>41%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,14374 + 0,53030 | + 0</td><td>0,3866</td><td>1,4719</td><td>59%</td></tr>
<tr><td></td><td></td><td></td><td>2,5121</td><td></td></tr>
</table>

Gender Model: Male Driver
Scenario with DRIP inactive, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,72210 + -0,26523 + 0,18794 + 0 + 0 |+ 0,25854 + -0,17390 + 0,15698 + 0,16988 + -0,07357 + 0,22979 + 0,08596 + -0,00296</td><td>1,2955</td><td>3,6529</td><td>71%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,41172 + 0,82657 | + 0</td><td>0,4149</td><td>1,5141</td><td>29%</td></tr>
<tr><td></td><td></td><td></td><td>5,1671</td><td></td></tr>
</table>

Gender Model: Male Driver
Scenario with DRIP active, Navigation active, and Radio active

<table>
<tr><th rowspan="2">Alternative</th><th colspan="2">Utility</th><th rowspan="2">Exponent</th><th rowspan="2">Probability</th></tr>
<tr><th>Expression</th><th>Value</th></tr>
<tr><td>Transit traffic road (A)</td><td>0,72210 + -0,26523 + 0,18794 + 0 + 0 |+ 0,25854 + -0,17390 + 0,15698 + 0,16988 + -0,07357 + -0,22979 + 0,08596 + -0,00296</td><td>0,8359</td><td>2,3069</td><td>60%</td></tr>
<tr><td>Local traffic road (N)</td><td>0 + 0 + 0 + -0,41172 + 0,82657 | + 0</td><td>0,4149</td><td>1,5142</td><td>40%</td></tr>
<tr><td></td><td></td><td></td><td>3,8212</td><td></td></tr>
</table>