DO DRIVERS CARE ABOUT THE HARM THEY CAUSE?

A STATED PREFERENCE EXPERIMENT TO DETERMINE HOW DRIVERS VALUE THEIR CONTRIBUTION TO AIR POLLUTION, NOISE AND SAFETY

by

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Summary

Traveling and road transport are inseparably bound up with modern life. To a large extend, todays prosperity is the result of our ability to transport people and goods fast and cheap. However, this comes with a price. Traffic jams, noise, air pollution and accidents are some of the negative effects of the ever increasing amount of road traffic. Many of these effects are not carried by the driver, while almost all benefits are.

From a macroscopic point of view it is reasonable to defend a system where many costs are paid by society, while the benefits are gained by individual drivers, as long as total costs are smaller than total benefits. Hence, a symptom of such a system is that those who make the decision to make a trip do not make an overall trade-off. They only take the benefits into account and not the costs. As a result, drivers have the incentive to drive more and choose the shortest and cheapest routes for them personally. This leads to even more costs for society and a decrease of societal welfare.

To optimize societal welfare, several solutions are available. In some cases it can be achieved by regulation and infrastructural policies. Often this solution is too rigid. A second type of solution is road pricing. Although this type of taxing does increase societal welfare, it has also disadvantages: it gives the 'right to risk lives', it's often expensive and cannot handle compensation. A third option to increase welfare is to inform the driver about the consequences of the decisions made by the driver. This is based on the idea that, up to a certain level, people are altruistic: the utility of road use to the driver is influenced by the effects it has on others. In this view, the reason why drivers currently are not behaving in a more desirable way is because of a lack of information: if one does not know the differences between two routes in terms of costs for society -the external costs-, one cannot take them into account. Till now, it was unknown how drivers take these costs into account in route choice behavior when they know about the magnitude of the costs.

This leads to the objective to determine how Dutch drivers value externality based attributes.

Previous studies always focused on the valuation of external costs, like air pollution, *on* the driver instead of the valuation *by* the driver of the effects caused by himself. To find out what the valuation of the externalities is, a utility function is determined. In a utility function, all relevant attributes together determine the utility of the trip to the driver. In this study, the attributes of the utility are travel time, monetary travel costs, air pollution, noise and safety. The driver related attributes which are taken into account are trip purpose, income, gender and age.

A web based stated preference survey was conducted to gather the necessary data. The survey was designed using an orthogonal array to maximize the efficiency of the questionnaire. In total 178 respondents participated in the survey. Those respondents had to answer questions in two sections. In the first section people were asked about some characteristics, like gender and age. The second section consisted 18 stated preference questions, with two options per question. The software package BIOGEME was used to estimate the relative and quantitative importance of the attributes in the utility function. This was done both with a multinomial logit model and a multinomial probit model. The analysis shows that the multinomial logit model gives a slightly better fit than the multinomial probit model.

All externality related attributes are found to be significant: people are willing to given up some time and money to reduce the effects on society of their behavior. Drivers value safety about three times higher than noise and air pollution. Noise is considered to be the least important externality for drivers. Older people care less about money, also when income is taken into account. People with higher incomes value time three times higher than those with low incomes. Professional drivers care substantially less about money, noise and air pollution and more about time. Younger driver care less about safety of others than older drivers.

The value of time is found to be somewhere between €5 and €19 per hour. This is close to the €20 per hour found in a revealed preference study in Copenhagen. The value of safety is found to be approximately €160.000. This is within the range found in previous work, which found a willingness to pay for reducing one casualty of €152.000 to €316.000.

The multinomial logit model turned out to give a slightly better fit than the multinomial probit model. For the entire sample, a ρ^2 of 0,12 was found for the logit model, while a value of 0,11 was found for the probit model. Fits for sub-samples lay between 0.09 and 0.43. This is a reasonable goodness of fit.

Based on these findings, it is concluded that drivers are willing to make a trade-off which includes the external costs they create.

Samenvatting

Reizen en wegverkeer zijn onlosmakelijk verbonden met het moderne leven. Voor een groot deel is de welvaart vandaag de dag het resultaat van de mogelijkheden om mensen en goederen snel en goedkoop te verplaatsen. Echter, hier moet wel een prijs voor betaald worden. Files, geluidsoverlast, luchtvervuiling en ongevallen zijn een aantal van de negatieve effecten van de immer groeiende hoeveelheid verkeer. Veel van deze gevolgen worden niet gedragen door de bestuurders maar door de maatschappij, terwijl de meeste opbrengen wel ten goede komen aan de bestuurder.

Macroscopisch gezien is het redelijk om een systeem te verdedigen waarbij de kosten voor rekening komen van de maatschappij, terwijl de baten ten goede komen aan de individuele bestuurders, zolang de opbrengen maar hoger zijn dan de kosten. Echter, een symptoom van zo'n systeem is dat de personen die de afweging moeten maken geen alles omvattende afweging maken. Ze kijken hoofdzakelijk naar de baten, niet naar de kosten. Het gevolg hiervan is dat het maatschappelijk welzijn afneemt.

Om het maatschappelijk welzijn te optimaliseren zijn er verschillende oplossingen voor handen. In sommige gevallen kan het worden bereikt door middel van regelgeving en infrastructuurbeleid, maar vaak zijn deze oplossingen niet toereikend en te rigide. Een andere oplossing is het belasten van weggebruik. Ondanks dat deze oplossing het maatschappelijk welzijn vaak ten goede komt, kent de oplossing ook enkele nadelen, waaronder de prijs van invoering en gebruik van een beprijzingssysteem. Daarnaast kan het systeem niet omgaan met de financiële compensatie van de slachtoffers. Een derde oplossing zou kunnen zijn om mensen informatie te geven over de gevolgen van hun gedrag. Het idee erachter is dat mensen tot op zekere hoogte altruistisch zijn en zich de gevolgen voor anderen aantrekken door hun gedrag aan te passen. In deze benadering is de reden dat mensen nu de kosten die voor rekening komen van de maatschappij niet meenemen in hun afweging om en hoe een rit te maken het niet hebben van informatie over de gevolgen. Tot op heden was het onduidelijk in welke mate bestuurders hun routekeuze laten afhangen van de kosten voor de maatschappij (de externe kosten) als ze wel op de hoogte zijn van deze gevolgen.

Dit leidt tot het doel om te bepalen hoe nederlandse bestuurders externe effecten waarderen.

Eerdere studies waren meestal gericht op de waardering van de externe kosten *op* de bestuurder, in plaats van wat de waardering voor de externe effecten was *door* de bestuurder die andere ervaren. Om uit te zoeken wat die waardering is, is er een nutsfunctie opgesteld. In een nutsfunctie worden alle relevante attributen opgenomen, die samen het nut van de rit voor de bestuurder vormen. In de nutsfunctie in deze studie zijn reistijd,

reiskosten, luchtvervuiling, geluidsoverlast en onveiligheid opgenomen. Daarnaast zijn de eigenschappen inkomen, leeftijd, geslacht en reisdoel meegenomen in het onderzoek.

Een online vragenlijst is opgesteld om de benodigde gegevens te verzamelen. De vragenlijst is opgesteld op bais van een orthogonaal array om de efficiëntie van de vragenlijst te maximaliseren. In totaal hebben 178 mensen de vragenlijst ingevuld. De respondenten moesten twee groepen van vragen invullen. De eerste set omvatte vragen over de karakteristieken van de chauffeur, zoals de leeftijd en het inkomen. De tweede set bestond uit 18 stated preference vragen, met twee opties per vraag. Het softwarepakket BIOGEME is gebruikt om aan de hand van de met de vragenlijsten verkregen gegevens een schatting te maken van de parameters in de nutsfunctie. Hierbij is gebruik gemaakt van zowel een multinomial logit model als een multinomial probit model. Analyse van de resultaten laat zien dat het logit model een iets beter fit geeft dan het probit model.

Alle onderdelen van de nutsfunctie blijken significant van invloed op het nut van een reis: mensen zijn bereid om geld en/of tijd op te geven om de externe effecten die ze genereren te reduceren. Mensen waarderen veiligheid daarbij ongeveer drie keer zo hoog als geluidsoverlast en luchtvervuiling, waarbij geluidsoverlast nog iets lager scoort dan luchtvervuiling. Oudere mensen geven minder om geld, ook als hierbij de hoogte van het inkomen in acht wordt genomen. Mensen met hoge inkomens waarderen reistijd drie maal zo hoog als mensen met een laag inkomen. Jongeren geven daarnaast minder om de veiligheid van anderen dan oudere bestuurders.

De waardering van tijd ligt in het onderzoek op een waarde tussen €5 en €19 per uur. Dit ligt dichtbij de waarde die gevonden is bij een onderzoek uit Kopenhagen. Daar vond men een waarde van €2 per uur. De waarde van veiligheid die gevonden is, ligt op ongeveer €160.000 per slachtoffer. This is aan de onderkant van de waarden die gevonden zijn in een eerdere studie, waar een waarde van een slachtoffer bepaald is op €152.000 tot €316.000.

Het logit model blijkt een iets beter fit te geven dan het probit model, met een rho^2van 0,12 tegen ρ^2=0,11 voor het probit model. Deze goodness of fit is een redelijk resultaat voor dit type onderzoek.

Gebaseerd op dit onderzoek kan geconcludeerd worden dat bestuurders bereid zijn hun gedrag aan te passen aan de gevolgen voor anderen.

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1 Introduction

1.1 Background of the research

Traveling and road transport are inseparably bound up with modern life. To a large extend, today's prosperity is the result of our ability to transport people and goods fast and cheap. However, this comes with a price. Traffic jams, noise, air pollution and accidents are some of the negative effects of the ever increasing amount of road traffic. Many of these effects are not carried by the driver, while almost all benefits are.

From a macroscopic point of view it is reasonable to defend a system where many costs are paid by society, while the benefits are gained by individual drivers, as long as total costs are smaller than total benefits. Hence, a symptom of such a system is that those who make the decision to make a trip do not make an overall trade-off. They only take the benefits into account and not the costs. As a result, drivers have the incentive to drive more and choose the shortest and cheapest routes for them personally. This leads to even more costs for society and a decrease of societal welfare.

This problem is studied since the 1920's by Pigou (1920). He proposed a system where drivers pay an amount of money as much as the monetarized costs paid by society. But because of some drawbacks of the system, it is still not a complete solution of the problem. In this study the possibilities of providing information to drivers about the consequences of their behavior are explored.

1.1.1 Terminology

Before possible solutions to the problem of decreased societal welfare are discussed, some of the terminology will be described to avoid vagueness in further reading.

Figure 1.1 shows how the different components interact.

Externality In economics, an externality of an economic transaction is an impact on a party that is not directly involved in the transaction (Wikipedia, 2007). In this case, prices do not reflect the full costs or benefits in production or consumption of a product or service. In transport, it is the impact on others than the driver when making a trip. For example, when a driver passes an urban area, the people living in that area suffer from the noise and air pollution of the driver's vehicle.

External cost is the quantification of an externality. Thus, unsafety is the externality while the number of casualties is the external cost. It is calculated that the external costs of transport are large and uncertain. It is estimated at approximately 7,3% of European Union gross domestic product. The most important categories of external cost are accidents, air pollution and climate change. Congestion is the largest component in many urban areas (Schreyer et al., 2004). Not all externalities lead to external costs: external benefits also exist, but these are insubstantial in the case of road traffic. Therefore, the focus will be on external costs.

Internalization of external costs is the process of transferring the external costs from the not involved to the involved party (e.g. from society to road users). On of the methods to do this is by taxing the driver.

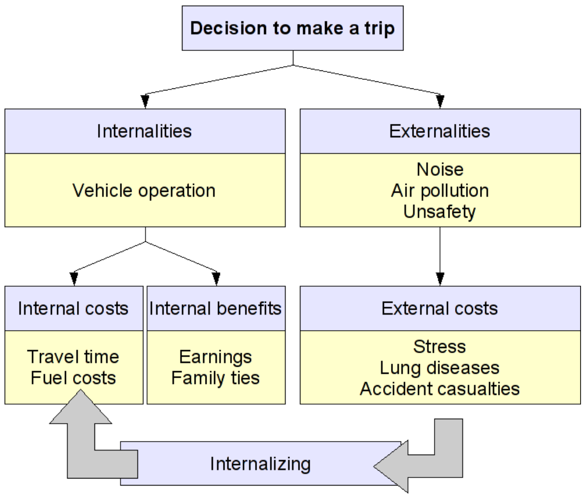


Figure 1.1 The terminology modeled

1.1.2 Different aproaches to increase societal welfare

Economists aim at increasing societal welfare and therefore, the situation explained in the prior paragraph can be assumed as a problem worth to be solved. To solve this problem, drivers have to make decisions based on *all* costs and benefits, instead on only partial costs and benefits. If this is not the case, societal welfare will be sub-optimal. Several solutions are available to this problem:

Regulation and infrastructural policies One solution is to force the driver to change his behavior. For example, one hour before a school begins, drivers are forbidden to pass it to avoid accidents with children. This solution is very inflexible, but can be very effective in some special cases. These are all focussed on avoiding external costs. If no external costs are created, they also do not have to be taken into account and as a result, societal welfare will increase.

Pigouvian taxing A more flexible system is also the best known and most widespread way of internalizing external costs: taxing the road user. This is called Pigouvian taxing, after Pigou (1920), who introduced the concept of road pricing. Nowadays, road pricing is introduced in different ways on various locations. The London Congestion Charging is a famous implementation of road pricing to internalize the externality congestion. Also in Copenhagen and Singapore the focus is on congestion. By publishing the Green Paper 'Towards Fair and Efficient Pricing' (European Commission, 1996), the European Commission shows the intention to use electronic road pricing (ERP) not only for internalizing congestion costs, but also for other externalities such as air pollution and noise. Therefore, it is likely more road pricing systems will be implemented in the near future.

In figure 1.2 the idea of taxing to increase societal welfare is shown. In the figure marginal costs and benefits are given for a certain activity Q. Marginal costs and benefits are the costs and benefits which are added when one driver is added to the network. Under normal circumstances an individual takes into account what the marginal personal benefits (MPB) are and what the marginal personal costs (MPC) are. This leads to a situation where people undertake a trip only in case $MPC \leq MPB$. Adam Smith's invisible hand thus secures personal welfare maximisation at the equilibrium Q_0.

As mentioned earlier, not all costs are at the driver's expense. The marginal societal costs (MSC) line shows the marginal external costs (MEC) added to the MPC. Now, maximal societal welfare would be reached at Q^*. To reach this optimum, a tax t^* must be added to the MPC. At the old value Q_0, the driver will now compare MPB with MSC and will draw the conlusion that the costs are higher than the benefits. The benefits are now only higher than the costs in case the activity Q is left of Q^* in the figure. In this way, the driver will take all costs into account with a higher societal wefare as a result.

Although Pigouvian taxing can be a useful tool to increase societal welfare, the (implementation of the) idea has some serious drawbacks:

- Charging the driver for the air pollution he causes, gives the driver 'the right to pollute', as the environment apparently can be compensated by measures paid for by the driver. However, this argumentation is hard to maintain for other externalities. For example, the value of a human life could perhaps be calculated (based on the economic losses and the suffering of relatives and friends), but nobody would claim to have the right to risk the life of others just because he paid for it. We want to avoid casualties, as long as it can be achieved by using a reasonable amount of resources.
- Implementing a road pricing system is often very expensive. In case of the London Congestion Charging system, 60% of the revenues are spent on administration and operating the system (Baum, 2008).

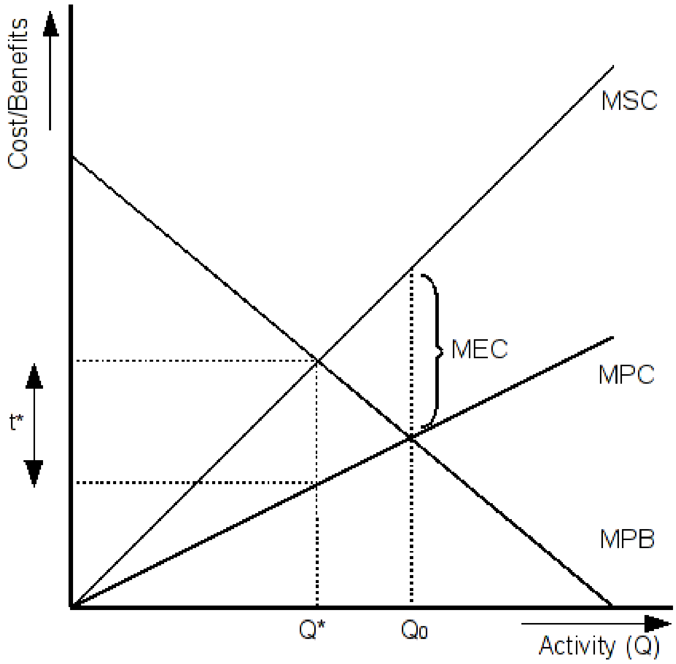


Figure 1.2 Pigouvian taxing: marginal costs and benefits

- Mayeres (2002) argues that the design of new road pricing schemes should take into account the already existing taxes. As it is unlikely that governments abolish existing taxes, a road pricing scheme which can maximize social welfare, is theoretically impossible.
- It is problematic to compensate those who have to carry the external costs. Therefore, it is preferred to prevent or at least reduce these costs. This is not by definition the most optimal way to increase welfare.

Informing the driver A third option to increase welfare is to inform the driver about the consequences of his decisions. This is based on the idea that, up to a certain level, people are altruistic: the utility of road use to the driver is influenced by the effects it has on others. In this view, the reason why drivers currently are not behaving in a more desirable way is because of a lack of information: if one does not know the differences between two routes in terms of external costs, one cannot take them into account.
A system based on providing information can be implemented instead of a road pricing system. But it can also be implemented next to such a system or next to regulation or infrastructural policy. This makes it a very versatile system. In case the information is available, it is unknown to what extend drivers take into account the costs society has to carry when the driver makes a trip. This study is conducted to find out how drivers deliberate the external costs.

1.1.3 Attributes of the utility

All kind of aspects -or attributes- influence the utility of a trip to the driver. To know the effects of adding an attribute to the consideration of the driver on the utility, it is necessary to know how the driver values this attribute. Three types of attributes can be distinguished:

- **Route related attributes** are the same for every user of a certain route. The length of a route is one example, just like the number of residents living near the route.
- **Driver related attributes** are characteristics of the driver: the color of his eyes, gender or income are examples.
- **Externality related attributes** Externalities are often not taken into account in studies about route choice behavior. Yet, in this study the focus will be on these attributes.

1.2 Research Questions

This research is carried out to be able to determine theoretically to what extend a system based on suppling information is capable of increasing societal welfare.
The attitude towards safety and the awareness of sustainability differs between drivers but also between countries and therefore results are location dependent. The study has a Dutch background, and therefore only drivers on Dutch roads are part of this study. No attention will be paid to the possible differences between the Dutch and other nationalities on Dutch roads. The main research question in this study therefore will be:

How do Dutch drivers value externality based attributes?

Many variations between drivers can be distinguished, but it is expected that the main differences in behavior are between drivers differing in economic motivations to make a trip. The three groups distinguished in this study are commuters, leasure drivers and professionals (those who earn their money while on the road). Conclusions for these groups may be applied to drivers with the same characteristics, like gender or income.

To be able to answer the main research question, several more detailed questions have to be answered:

1. **Which route related, driver related and externality related attributes are relevant in this study?**
   There are many attributes, but not all of them are relevant. The fact that some people have brown eyes and other do not, will not influences their route choice behavior. The contribution can be expressed in the sign of the parameter and the magnitude.
2. **How can the attributes be quantified?** Some attributes are straight forward, like gender. But others, especially the externality based attributes are more complicated. What is air pollution, for example?
3. **How do relevant attributes influence the utility of a trip for a driver and how can the effect on the trip utility be determined?**

1.3 Overview of the report

In figure 1.3 an overview of the study is given. The setup of the report is based on this approach. In chapter 2, an overview of existing research will be given. This overview is split up in different themes which together describe the current state of art and the position of this study. It confirms the problem which was explicated in the previous two paragraphs.
Chapter 3 explains the theoretical approach and background of the study. The chapter also covers how the study was conducted from a practical point of view and describes what the pitfalls are in conducting a stated preference survey and how these are avoided in this study. Chapter 4 covers the results from the modeling. It also combines the information from the literature study in chapter 2 with the outcomes. The last part of the chapter covers the validity and reliability of the results. Together with chapter 3, chapter 4 covers the modeling block in figure 1.3.
Chapter 5 discusses the outcomes and what the remaining problems are. It also describes what the outcomes mean for society and possible future studies.
Chapter 6 holds the conlusion.

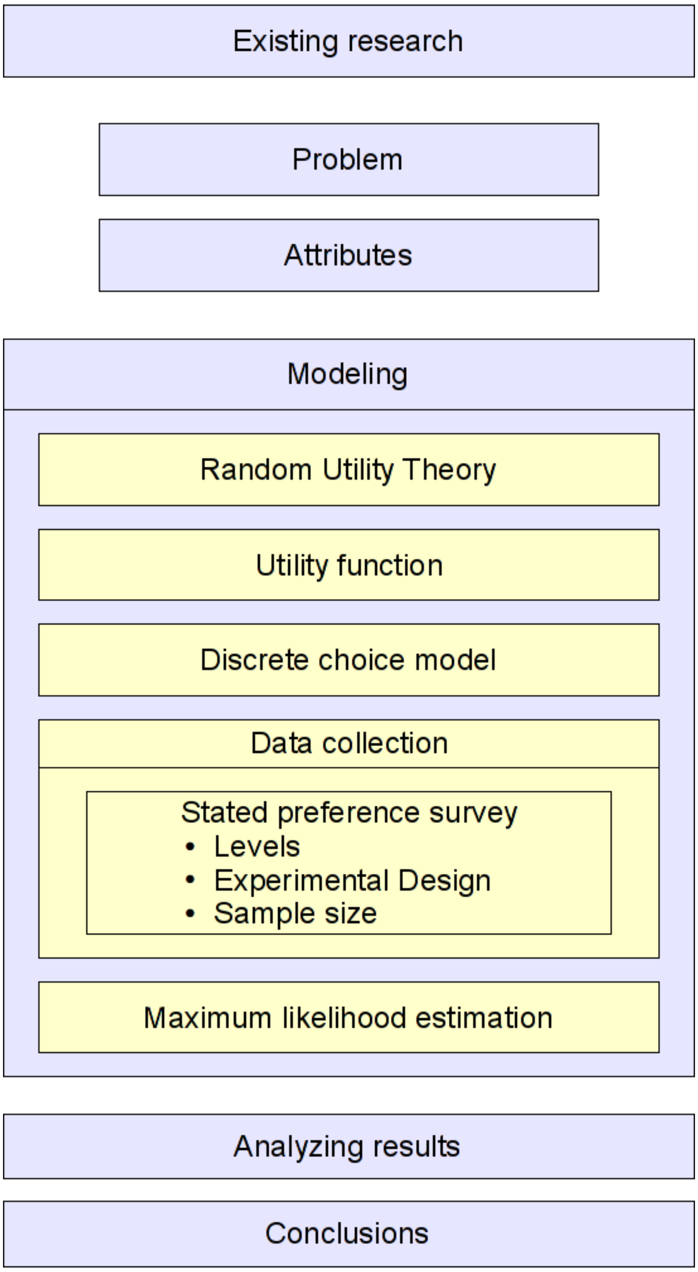


Figure 1.3 Visualization research approach

2

Overview of existing research results

In the field of road pricing, route choice behavior and valuation of external costs of road traffic a lot of research has been carried out. But the combination of many attributes and the Dutch situation specifically has not been studied before, as the overview below will show.

To create a framework for information supply to drivers, a lot of knowledge is needed. Large parts of this knowledge is already there. Four main fields can be determined:

Externalities and external costs It is important to know which externalities are studied or have been part of a study, because in this way the impact per externality on society can be estimated. Because the number of externalities is very long, only those influencing societal welfare most, will be included in the study.

Driver related attributes Some characteristics influence the behavior and attitude of drivers more than others. Also, the number of driver's characteristics is endless. Only the most important ones can be included, so those have to be found in literature.

Valuation of externalities Externality related attributes have not been studied before from a driver's point of view. Several studies have been carried out to determine the value of safety, air pollution or noise, but all of them are from the victim's point of view. Parumog et al. (2006), for example, focused on the air pollution drivers themselves suffer from, not on the drivers' contribution. To get an idea of the valuation, these studies are part of this overview. These valuations can be used as reference for the valuations found in this study.

Stated preference survey techniques Though stated preference surveys are not part of the present research topic, some words will be dedicated here to the state of the art in stated preference survey techniques, an area of research that is relative young and in development.

When the overview on the first three fields is given, it becomes clear whgat information is missing and what information is needed in the rest of this study.

2.1 External costs and externalities

The effects of individual drivers on society and other traffic are broad and widespread. Schreyer et al. (2004) have given a comprehensive list of externalities. The list as given by Schreyer et al. (2004):

- accidents,
- noise,
- air pollution,
- climate change,
- nature and landscape,
- congestion and
- additional costs in urban areas.

Some of the items in the list are broad and contain several effects.
For example, air pollution. This item contains particulate matter (PM_{10}), CO, NO_x and other pollutants. But also 'additional costs in urban areas' is actually a broad, non quantified item.

2.2 Driver related attributes used in route choice behavior

Driver characteristics influences driving behavior significantly. E.g., young people get involved in accidents much more often than middle aged drivers because of differences in driving experience and risk perception. Characteristics found most often are:

- age
- gender
- income
- house rent
- distance from home to work
- type of user
- trip starting time
- marital state
- years of education

Some of these characteristics are substitutes for others. For example house rent is used as a substitute for income. Parumog et al. (2006) used age, sex, marital state, years of education and income and found all of them to be significant.

2.3 Valuation of externalities

Valuation of externalities has been studied extensively. Usually the results were presented as the willingness to pay (WTP) for the attribute. Ubbels and Verhoef (2004) studied the acceptance in the Netherlands of road pricing systems. Several road pricing techniques were compared in order to decide which road pricing system could be implemented in which circumstances. This study showed people are willing to pay, as long as they personally benefit from the road pricing system by reducing travel time.

Iragüen and Ortúzar (2004) focused on the willingness to pay for reducing fatal accident risk in urban areas. This study points out the problem of the unique risk perception of all individuals. Not only will two individuals perceive a given risk differently, different types of risk are also perceived differently.
Experiments aimed at measuring risk related values must be designed carefully with a clear definition of the type of risk considered and ensuring subjects consider the same risk concept. Safety of other road users is one of those risk related values.

Parumog et al. (2006) studied the value of traffic externalities for commuters in Manila, Philippines. In this stated preference experiment travel time, travel costs, air pollution, noise and safety were included. The focus of Parumog et al. (2006) was on developing countries and on the evaluation of some modeling specifications. The study showed that the explanatory power of the noise and air pollution attributes in the utility for the driver is marginal. All other attributes, including the ones related to the driver (age, sex and income) did influence the utility. The air pollution and noise values were based on the effects *on* the driver, which differs from this study.

The value of safety has been discussed in a number of studies. Landefeld and Seskin (1982) discussed the value of safety in the United Kingdom. Rizzi and Ortúzar (2003) successfully estimated the value of preventing a statistical fatality. They found that to reduce the number of fatally wounded, a driver was willing to pay $0,23 to $0,34 for one highway route in Chile. The willingness to pay was found to be significant for all groups except young male drivers. The study also showed that female drivers value safety higher than men.

Yin and Lawphongpanich (2006) addressed issues relevant to internalizing traffic emission externalities. They show that road pricing can be counter productive when only one externality, like congestion, is included in the system. By charging toll based on both congestion and air pollution they could reach a Pareto-maximum in the system.

Galilea and Ortúzar (2005) used a stated preference experiment to estimate the WTP for reducing noise levels. This WTP was the WTP of those who suffered the noise. It did not take into account the amount drivers were willing to pay to compensate their noise. The study shows that noise -at least for the victims- is a relevant attribute.

Tseng and Verhoef (2008) showed that the value of time depends heavily on the time of the day. Drivers value one minute more in bed higher than one minute earlier at the office. Early commuters are willing to pay more to leave one minute later than commuters who leave home later during rush hour. Tseng and Verhoef did not take into account the different reasons why people are on the road. This is likely to influence the valuation of time.

Bickel (2006) is the only one who focused on the willingness to pay for safety from the perspective of the driver. In that study, no results were published for specific types of drivers. Willingness to pay values of €19.000 for slight injured, €236.000 for severe injured and €1.782.000 for fataly wounded were found. No information could be retreaved about the relations between the number of severe and slight injured used in that study.

In general, studies valueing noise and air quality find that there are only a limited number of socio-economic variables which have significant influence on these values: income is the key variable, followed by household size and household composition and factors related to self-selectivity (Wardman and Bristow, 2004).

Most studies investigate the valuation of only one or two attribute at the same time. Calthrop and Proost (1998) have shown that policy interventions into one of the externalities air pollution, noise, accidents (safety) or congestion affect the other externalities as well. Therefore valuation studies should include all of these attributes.

2.4 Stated preference survey techniques

The stated preference (SP) approach is a generalization of contingent valuation method (CVM), where individuals express choices between alternative scenarios characterized by a number of relevant attributes. Concerns about the CVM approach, in particular that it is more vulnerable to strategic bias, while an SP approach more closely resembles everyday decision making, have provided a stimulus to use SP in the valuation of noise (Wardman and Bristow, 2004; Slensminde, 1990).

Important work has been done by Louviere et al. (2006) and Ortúzar (2000) in standardizing the setup of stated preference surveys. Bateman et al.(2002) contributed by focusing on the economic valuation with stated preference techniques. The progress in understanding and developing orthogonal arrays to design experiments helped the SP technique to become a useful tool. Muizelaar and Arem (2007) implemented the techniques proposed by Louviere et al. (2006) and gave a good description of the steps.

Tseng and Verhoef (2008) provided additional evidence on the ability of stated choice to provide useful results in the context of the valuation of environmental externalities.
Random taste variation was found to be appreciable, and allowing for it considerably improved the explanatory power of the models.

2.5 Conclusion

The research overview shows a lot is known about the valuation of internal costs by drivers and about a strict economical determination of external costs. Also the way victims value the external costs they carry is studied, with reliable outcomes. Only the way drivers value the external costs they cause is not studied before.
Attributes that are likely to be most relevant are: safety, noise and air pollution. These are

the most important external costs to study.
Income, age, gender and purpose of the trip are all proven relevant characteristics which influence the valuation of the external costs.
The literature review also shows SP is a proven tool to get valid research results.

3 Approach

To answer the research questions, the first step is to determine which attributes should be concerned. This is done in paragraph 3.2. The next step, which is covered in paragraph 3.1, is to describe how the utility of attributes can be determined and how the necessary data should be collected. After the data is collected (paragraph 3.5), a step-by-step guide on how to process the data is needed. At last, the possible pitfalls and biases are discussed.

3.1 Random Utility Theory

The use of random utility models is a well-established method for describing discrete choice behavior. This method is also applied in this study.
In the theory, it is assumed that for each given option, each alternative accommodates a certain utility to the driver, and the driver will choose the alternative which brings the most utility. With this assumption, the relative importance of the various attributes in the utility function U_{iq} can be determined.

The probability of choosing alternative i from choice set C_q by decision maker q is:

$$P_n(i) = P_r(U_{iq} > U_{jq}), \forall j \epsilon C_q \tag{3.1}$$

3.2 Attributes of the utility

Three types of attributes are distinguished:

1. route related attributes,
2. driver related attributes and
3. externality related attributes.

Two route related attributes will be included in the study. These are used as reference points. The reason why two types are used where one would be sufficient is because people value time very differently and therefore it will be easier to draw conclusions when both travel time and monetary travel costs will be included. It makes it also easier to validate the results.

The two route related attributes are:

Travel time Obviously, time is a very important attribute. Most drivers want to reach their destination as soon as possible. Travel time is expressed in minutes, both in the utility function as in the survey.

Monetary travel costs Also costs are important in route choice behavior. Some people cannot afford to spend much more on transportation, others would love to pay more when they could save time. Costs are expressed in Euros, both in the utility function as in the survey.

The focus in this study is on externality related attributes. Three are determined to be the most important ones, and are included in the survey. It is important to realize that the externalities where these attributes are based upon, are caused by the driver: it is not about the current air quality, but about the contribution of the driver to decreasing air quality.

Air pollution Air pollution is a combination of several components. Basis of the values in this survey is the Air Pollution Index (API) of Hong Kong. The levels of the API are related to the measured concentrations of ambient respirable suspended particulate or particulate matter (PM_{10}), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and nitrogen dioxide (NO_2) over a 24-hour period based on the potential health effects of air pollutants.
Not all of these components are locally bounded. CO, for example is toxic, but only from a relatively high level. Therefore, only PM_{10} and NO_x will be included.
For this study, air pollution is calculated in casualties per year for the entire country.

Noise Noise will be calculated as casualties per year in the Netherlands. Similar to air pollution, casualties are both fatalities and seriously harmed people.

Safety of other road users The safety is about the others on the road, not about the driver himself. The numbers are counted for the whole of the Netherlands again and contain both seriously and fatally wounded.

All of the values are explained at the start of the survey, so people realize what their effect on the other road users is.

The driver related attributes are:

Trip Purpose As mentioned in chapter 2, most literature distinguishes two trip purposes: commuters and leisure drivers. We also define professional drivers as a separate group, because these people are paid while on the road and their valuation of time is very different from the other two categories. This results the the following groups:

- Commuter trips
- Professional trips
- Leasure/other trips

Respondents were asked to choose between these three at the start of the survey. The respondents are reminded to the choice they made when answering the other questions.

Income Many people often do not know their exact yearly income. Therefore, asking them for their gross annual income would result in too many empty responses. Because a modal income in the Netherlands is approximately €30.000, the three following income levels are used:

- €0 - €20.000
- €20.000 - €45.000
- €45.000 and more

Gender The gender of the driver can be of influence and is therefore included.

Age It is likely drivers of different ages value externalities differently. Older people have seen or were involved in accidents more often or because they have another mentality. Age is divided into three levels:

- 18-30 years old,
- 31-45 years old and
- 45+ years old.

To go short, the number of levels of each driver related attribute is three, except for the gender, that attribute has only two levels.

3.3 Utility Function

Before any attribute parameter can be estimated, the utility function itself has to be determined. For every individual the utility of an alternative is a combination of the observed attributes and the non-observed or unknown attributes. This can be described as the systematic utility V_{iq} and a random component ε_{iq}:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{3.2}$$

in which:

$$\begin{aligned} U_{iq} &= \text{Utility for individual } q \text{ and alternative } i \\ V_{iq} &= \text{Systematic utility for individual } q \text{ and alternative } i \\ \varepsilon_{iq} &= \text{Random utility for individual } q \text{ and alternative } i \end{aligned}$$

The attributes needed to be incorporated in the utility function will be described in paragraph 3.2.

Although Hess et al. (2008) show that asymmetrical response to increases and decreases in attributes occur, initially all the responses to changing attributes are assumed to be linear. Kato (2006) showed the value of time depends on the distance traveled. To be more precise, the value of travel time savings decrease as travel time increases. In the same study, it is expected that a constant value of travel time savings is sufficient for most studies.
No previous work was found on the valuation of the external costs of noise and air pollution by drivers is known, therefore without good reasons to assume otherwise, noise and air pollution are assumed to be linear.

Optionally, driver related attributes can be incorporated in the utility function, but this would increase the number of questions in de survey. The other option is to leave out these attributes and do more calculations on the same data set. The consequence is that in the latter option, the sampling and sample size need more attention.

The systematic part of the utility function is:

$$V_{iq} = ASC_i + \beta_1 * TT_{iq} + \beta_2 * MTC_{iq} + \beta_3 * N_{iq} + \beta_4 * S_{iq} + \beta_5 * AP_{iq} \tag{3.3}$$

where:

$$\begin{aligned}
ASC &= \text{Alternative specific constant of alternative } i \\
\beta_1 &= \text{Coefficient for travel time} \\
\beta_2 &= \text{Coefficient for monetary travel costs} \\
\beta_3 &= \text{Coefficient for noise} \\
\beta_4 &= \text{Coefficient for safety} \\
\beta_5 &= \text{Coefficient for air pollution} \\
TT_{iq} &= \text{Level of travel time for alternative } i \text{ and individual } q\text{, in minutes} \\
MTC_{iq} &= \text{Level of monetary travel costs for alternative } i \text{ and individual } q\text{, in €} \\
N_{iq} &= \text{Level of noise for alternative } i \text{ and individual } q\text{, in casualties} \\
S_{iq} &= \text{Level of safety for alternative } i \text{ and individual } q\text{, in casualties} \\
AP_{iq} &= \text{Level of air pollution for alternative } i \text{ and individual } q\text{, in casualties}
\end{aligned}$$

For model convergence, the attributes have to be independent. Information theory tells that data needs to have little or no collinearity. The problem with some of the above explained attributes is that they are not independent. This has to be solved or at least be recognized in the study.

3.4 Discrete choice models

A discrete choice model can be used to analyze and predict choice behavior of individuals. In this paragraph the most common discrete choice models are described, based on Ortúzar and Willumsen (2001).

In general, discrete choice models postulate that: 'The probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option' (Ortúzar and Willumsen, 2001).
The utility of an alternative is derived from it's characteristics and those of the individual (Lancaster, 1966). The observable utility is usually defined as a linear combination of variables, for example:

$$V_{train} = 0,35 - 1,2IVT - 2,5AT - \frac{0,25C}{I} \tag{3.4}$$

In this example, the relative influence of access time (AT) is about twice the influence of the in vehicle time (IVT). The variables represent the characteristics of both option and driver. The 0,35 in the example represents the unobserved or not included characteristics and is called the alternative specific constant (ASC).

3.4.1 Logit models

A logit model is an univariate binary model. That is, for dependent variable y_i which can be only one or zero, and a continuous independent variable x_i, that

$$Pr(y_i = 1) = F(x_i'b) \tag{3.5}$$

Here, b is a parameter to be estimated, and F is the logistic cumulative density function (CDF).

$$ln\left(\frac{P_i}{1-P_i}\right) = \alpha + \sum_{k=1}^{n} B_k x_{ki} + e_i \tag{3.6}$$

Multinomial logit Multinomial logit (MNL) is derived from the binary logit (BL) model. In essence a MNL model is a BL model with more than two options to choose from. The random terms are identically and independent Gumble distributed. In formula:

$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j \epsilon C_n} e^{\mu V_{jn}}} \tag{3.7}$$

where:

$$\begin{aligned}
P_n(i) &= \text{probability } P \text{ of choosing alternative } i \text{ by individual } n \\
d &= \text{choice set of individual } q \\
h &= \text{systematic utility of alternative } i \text{ for individual } q \\
V_{in} &= \text{utility function (see equation 3.4)} \\
\mu &= \text{scale parameter, related to the common standard} \\
&\quad\ \text{deviation of the Gumble variate by:}
\end{aligned}$$

$$\mu^2 = \frac{\pi^2}{6\sigma^2} \tag{3.8}$$

One characteristic of an MNL model is the Independentand Identically Distributed (IID) property of the error terms, which leads to Independence from Irrelevant Alternatives (IIA). This property is displayed in equation 3.9 (Muizelaar and Arem, 2007)

$$\begin{aligned} \frac{P_{ni}}{P_{nk}} &= \frac{e^{\mu V_{ni}} / \sum_j e^{\mu V_{nj}}}{e^{\mu V_{nk}} / \sum_j e^{\mu V_{nj}}} \\ &= \frac{e^{\mu V_{ni}}}{e^{\mu V_{nk}}} \\ &= e^{V_{ni} - V_{nk}} \end{aligned} \tag{3.9}$$

IIA requires that an individual's preference relative to another alternative should not change if a third alternative is introduced or dropped to the analysis. If a driver is twice as likely to choose the short route over the safe one, he should remain twice as likely to choose the short route over the safe one when a third route is introduced. That is not very likely. If, for example, the new route is faster than the short route and just as expensive and safe, it is much more likely the driver prefers the new route over the short route, while his appeal to the safe route does not change. This characteristic is a drawback when two or more alternatives are highly correlated.

MNL models have two other drawbacks: the model assumes every individual has the same 'taste' when it comes to decision making, because individuals have the same error distribution. Yet, variation in time cannot be taken into account.
Next to these serious drawbacks, MNL also has two important advantages. It is a simple model and it is easy to compute. The MNL model is the starting point in this study.

Conditional logit Conditional logit (CL) is very similar to MNL, but there is one distinctive difference. For CL only explanatory variables specific to the option are chosen, not to the decision maker (in this case: the driver). For example, if a person has to decide which route (safe or fast) he will take, MNL will use explanatory variables like the person being male or female or his age, but also the costs of the link. MNL will tell if a male is more likely to take the fast route rather than the safe route. CL will only have variables like the risk of hitting a pedestrian or the length of a link. As a result, CL will tell us what the most important factors are to base a decision on: travel time, comfort, costs, et cetera. In this survey the characteristics of the driver are important too as we want to know *drivers* behavior. For this reason,a CL model is not used in this study.

3.4.2 Probit models

The probit model is basically the same model as the logit model, but with a different CDF for F. In this case, logistic CDF for F is replaced by the normal CDF.

Multinomial Probit The multinomial probit (MNP) model, a popular alternative to the MNL model, is a generalization of the probit model by allowing more than two discrete, unordered outcomes. It can handle differences in 'taste'. Because MNP does not assume

IIA, some assume MNP is more accurate than MNL. R. Michael Alvarez and Jonathan Nagler seem to assume this (Alvarez and Nagler, 1998). But Kropko (2008) states MNP loses accuracy in other points involved in the computation. The conclusion Kropko draws is that MNL is preferred over MNP. This does not mean that IID, which leads to IIA, is something to be ignored.

Logit with correction factors Another option to overcome the IIA drawback in MNL models is to add correction factors to the equation of the probability. Two methods are described here: the C-logit method and the path-size logit method.

The first approach is to add a commonality factor to the standard MNL model. Based on equation 3.7, this results in:

$$P_n(i|C_n) = \frac{e^{\mu V_{in} + CF_{in}}}{\sum\limits_{j \epsilon C_q} e^{\mu V_{jn} + CF_{jn}}} \tag{3.10}$$

where:

$$CF = \text{Commonality Factor}$$

This approach was proposed by Cascetta et al. (1996). Four different forms of CF are proposed, yet good documentation on when to use which CF does not exist and therefore this type of model will not be used in this study.

Path-size logit (PSL) models try to incorporate behavioral theory to eliminate the drawback of MNL models. Similar to C-logit, path-size logit adds a correction term to the standard MNL model. Yet this model assumes that an overlapping path is not perceived as a different alternative.

The standard PSL models are not capable to determine any difference in length of paths using the link. Ben-Akiva and Bierlaire (2003) proposed a PS factor including the length of the shortest path in the choice set. Unfortunately, PSL models do not correctly capture the correlation structure, as Frejinger and Bierlaire (2007) show. However, the most important problem with this type of model is the way it relies on the length of a path. This is hard to translate to the type of route choice problem in this study.

Nested logit Nested logit models are used when some alternatives have common attributes. These alternatives are placed in one nest. A major shortcoming of nested logit models is that an attribute can only be member of one nest. For example, in mode choice models is it possible to place the public transport nodes in one nest and the private transport in another nest. In this study, alternatives are persons who could be part of different nests. Therefore, nested logit is not useful for this study.

To overcome the problem of nested logit, cross-nested logit (CNL) is introduced. In this type of model alternatives can be placed in several nests. CNL is capable of capturing correlation between alternatives, but like other logit models it cannot capture the variation among individuals and in time. To be able to use CNL models, at least three alternatives have to be present in every question.

Mixed logit Mixed logit is a combination of probit and logit. It is sometimes called probit models with a logit kernel. It can cope with random taste variations among individuals, correlation of unobserved factors over time and for unrestricted substitution patterns between alternatives (van Dijck, 2007; Train, 2003). These models can be used for route choice, according to Bekhor et al. (2002). Iragüen and Ortúzar (2004) obtained superior fits with ML in comparison to MNL, but the WTP estimates for both models did not show significant variations. When it comes to computational performance, mixed logit performs somewhere between MNL and MNP models.

Conclusions

- A multinomial logit model is preferred over an multinomial probit model, mainly because of the advantages in computing time. Also the results of multinomial logit models are often not inferior to the results of multinomial probit models (Kropko, 2008).
- Multinomial logit models can be extended to cope with dependent alternatives. But the way these extension are implemented are not useful in this study.
- Nested logit is not useful in this study, because an attribute is part of many possible routes, while nested logit cannot cope with that. Cross nested logit is, but only in situations with three or more options to choose from.
- Multinomial probit models can be used as long as computation time is reasonable.
- Mixed logit can be an alternative to multinomial probit in case of excessive calculation time of multinomial probit.

3.5 Data collection

3.5.1 Revealed Preference

One way to collect data related to route choice behavior is by using a revealed preference (RP) study. RP data is data about observed choices made by individual drivers.
It is far beyond the possibilities of this study to set up an RP case, because that would need large-scale implementations of information systems. The other option is to use data already collected in other studies. In various cities all over the world different road pricing systems are implemented to increase societal welfare. The data collected in these projects could be used to investigate the differences in behavior of drivers. But there are several serious problems when RP data is used. First of all, the useful cases are all situated outside the Netherlands. The second problem is that the most well-documented cases (London, Singapore and Copenhagen) all are cities, which is not a good representation of an entire network or society. Yet the most important reason why a RP study is problematic, is because it cannot cope with all relevant attributes and the characteristics of a driver. For

those attributes that can be covered, it is hard to determine the relative influence. Not in the last place because at the same time road pricing was introduced, other measures were taken. For example, the London bus system was upgraded at the same time the road pricing system was introduced. Because of all these drawbacks, RP is practically useless in this study.

3.5.2 Stated Preference

The survey can be conducted in several ways. Three main types can be distinguished:

1. Contingent valuation (How much do you want to pay for ... ?)
2. Scaled valuation (How do you value noise on a scale from 0 to 10?)
3. Choice experiment (two options: which option do you prefer?)

Contingent valuation has the drawback that people do not understand what the trade-off is between the different attributes. It is also shown that people, although willing to participate, do not give realistic answers (Kimenju et al., 2005). Scaled valuation only can give information about the relative importance between attributes. Choice experiments can determine next to the relative importance also an absolute value. These values can be compared with findings in other studies, which is an important indicator how reliable the results are. Because of this characteristic, a choice experiment is conducted.

In the survey individuals are asked about what they would do in a hypothetical situation. In this way data can be collected in a very effective way. Ortúzar (2000) covers both the methodology and possible applications of stated preference modeling techniques in a very comprehensive way. He also included some papers regarding reliability and validation of SP models.

Ortúzar distinguishes four steps in a SP data collection exercise. These steps form the basis of the setup in this study:

1. Identify the range of choices, the attributes to be considered and the levels of variation.
2. Design an initial version of the experiment and survey and use simulated data to check that the design allows to recover all the parameters of the model.
3. Develop a sampling strategy to ensure a rich and representative data set and pre-test the survey using a small stratified sample.
4. Evaluate the pre-test both in terms of quality and of the intuitive quality of the responses.

Afterwards, the survey can be held and the data can be analyzed.

3.6 Survey design

3.6.1 Setup

Based on literature, several driver related attributes are expected to be important as determinants for the utility of the externality related attributes. Therefore, in the first part of the survey, some questions will be asked about the respondent. These questions will be about their income, gender, age and the trip purpose. The trip purpose is assumed to be the same during the entire questionnaire. The second part of the survey is the stated choice experiment.

3.6.2 The number of levels and the levels of the attributes

In most cases where many factors are involved, a two stage experiment is conducted. The first stage is a orthogonal two-level factorial design experiment to rule out all unimportant factors. Afterwards, a new survey will be build to determine the correlation between the attributes that are left. This survey uses in most cases a three level experimental design. Cheng and Wu (2001) proposed an experiment where the data can be gathered in one exercise. In this case, the initial experimental design needs already three levels. This is done in this study. How the experimental design is done, is explained in paragraph 3.6.3.

The middle level of the attributes is based on realistic numbers and on averages. These are given in table 3.1. Although it is not important to be very precise in the determination of the middle level, it is important to use realistic values so that people can identify the situation much better.

Table 3.1 Levels

Levels	TT	MTC	N	S	AP
1	18	€3,75	10.000	15.000	20.000
2	20	€4,00	25.000	25.000	40.000
3	22	€4,25	40.000	35.000	60.000

Travel time The average trip length in the Netherlands is about 20 kilometers (Projectteam MON, 2008) at an average of about 60 km/h. This leads to a travel time of approximately 20 minutes.

Monetary travel costs If the distance traveled is 20 kilometers and the average monetary travel costs per kilometer is about €0,20, the travel costs for the trip are €4,00.

Noise In the Netherlands many people suffer from traffic noise. Every year 3% of the heart attacks are related to high blood pressure as a result of traffic noise (GezondheidsNet.nl, 2007). Every year tens of thousands of people suffer from noise in such a serious way their health is affected. Because it is hard to draw a line for whom suffer and who do not, this number is an estimation.

Safety The number of casualties in traffic decreases year by year for a few decades now. Yet the number of seriously injured and deaths is in total slightly more than 20.000 people per year.

Air pollution Alike noise, it is hard to prove a causal connection between air pollution and an exact number of casualties. But based on CBS (2008) the number of people negatively affected by traffic related air pollution is estimated at 40.000 per year.

Differences between the levels is based on the expected valuation of the attributes. To determine this expected valuation, an iterative process was started, resulting in several test surveys for a small number of people (four to six persons). In these surveys (two of them are shown in appendix A) the values where changed. If the attribute was assumed to be of importance, like travel time, the differences are relatively small to prevent other attributes to be overshadowed by this attribute. As an example:
If the travel time has huge differences between the levels and the difference between the number of noise related casualties is minimal, everybody would always choose in favor of travel time. In that case, the utility of noise could not be found.

At the end of the iteration process, respondents implied that the difference in time or money are so small that they had to include other attributes to make a good trade-off. Some of them also asked why the difference in travel costs was so small: they always only looked at the travel time first and made a trade-off between the other attributes. Others asked almost the same question, but said the difference in travel time was so small, they only focused on the travel costs and made a trade-off between the other attributes.
Because there is no way to determine what the perfect values are, the values at the end of the iterative process are used.

3.6.3 Experimental Design

SP experiments are used for estimating relative values and for forecasting. (Ortúzar, 2000) In the first case, the ratios of the parameter estimates are of interest. In the second case it are the parameter estimates themselves that are of primary importance. This difference is important when considering the efficiency of experimental designs. When forecasts have to be made, a second order design is preferred. In paragraph 3.6.2, the number of levels is determined at three.

Besides the attributes and their levels, it is also necessary to define the alternatives respondens can choose from in the survey. Two alternatives will be given in every question, because the number of attributes makes the questions relatively hard to answer. If people were asked to make a selection out of more options, people would give less reliable answers. (Hubert and Hanson, 1986).An example question in the survey is shown in table 3.2.

It is often proposed to add a ‘no purchase option’ (NPO), in case people find all options unacceptable. Because the possible benefits in relation to the routes presented in the survey are not clear enough, this option will be left out of the survey.

The most comprehensive design is the full factorial design:

$$q = n^a$$

where:

$$\begin{aligned} q &= \text{number of choice sets} \\ n &= \text{number of levels} \\ k &= \text{number of attributes} \end{aligned}$$

Our case would result in $3^5 = 243$ questions (five attributes with three levels). Clearly, this is too much to ask each respondent this number of questions. Even if the number of attributes is reduced, too many runs are needed to design a full factorial design. Reducing the number of questions per respondent is no solution, because the number of respondents has to be increased to unrealistic high numbers. This means the number of runs has to be reduced in another way in order to set up a useful survey. This is be done by using a fractional factorial design.

The experimental design is a Taguchi orthogonal array design, a so called L_{18} design (Taguchi, 1987). This means it ensures attribute combinations presented are varied independently. Several optimal 18-run orthogonal designs are presented by Ye et al. (2007). The 3^5 design is used in this study (table 3.3(a)). With this design it is possible to determine all primary effects of the attributes in the utility function and some secondary effects.

Table 3.2 Stated preference example question

	Travel time	Monetary travel costs	Noise	Unsafety	Air Pollution
O	18 min	€4,25	40.000	15.000	40.000
O	20 min	€4,25	10.000	15.000	20.000

To avoid fatigue, respondents have to answer no more than approximately 30 questions, given the complexity of the questions. Answering 18 questions is clearly within this number. It reduces the possible considered effects seriously, but it will at least be possible to determine the interactions between the attributes. And these are the most important effects we want to know.

The design of the stated preference questions is split into two parts. The first part is the design of the first set of alternatives, which is the just mentioned array. The second step is to determine the differences between the first and the second set of alternatives. In cases nothing is known about the attributes, the most ideal approach is to change as many attributes as possible and change them in a fixed pattern. In case of a two level design, a possible pattern for the second set of alternatives is the foldover design. It replaces all 0's by 1's and all 1's by 0's (Louviere and Timmermans, 1990). This type of design is from a mathematical point of view the most powerful, but has a major disadvantage in this study. Because the different levels are hard to understand, it is not the best solution to change as much attributes as possible. Next to that, the sign of the β's is already

Table 3.3 Design

(a) Alternative 1

Run	TT	MTC	N	S	AP
1	1	1	1	1	1
2	0	0	1	1	1
3	0	1	0	1	2
4	0	1	2	2	2
5	0	2	1	2	0
6	0	2	2	0	1
7	1	0	0	2	2
8	1	0	2	1	1
9	1	1	1	2	1
10	1	1	2	0	0
11	1	2	0	1	0
12	1	2	1	0	2
13	2	0	1	0	2
14	2	0	2	2	0
15	2	1	0	0	1
16	2	1	1	1	0
17	2	2	0	2	1
18	2	2	2	1	2

(b) Alternative 2

Run	TT	MTC	N	S	AP
1	1	2	0	0	0
2	1	0	0	0	0
3	2	1	0	0	1
4	1	1	1	1	2
5	0	1	2	2	1
6	1	2	0	0	0
7	1	1	0	1	1
8	2	0	0	0	0
9	2	2	1	0	0
10	1	2	0	2	0
11	1	1	2	1	0
12	2	1	1	0	0
13	2	1	1	0	1
14	2	2	0	0	0
15	1	1	2	2	0
16	0	1	1	2	2
17	2	2	1	1	1
18	2	2	2	2	1

(c) Differences

Run	TT	MTC	N	S	AP
1	0	1	-1	-1	-1
2	1	0	-1	-1	-1
3	2	0	0	-1	-1
4	1	0	-1	-1	0
5	0	-1	1	0	1
6	1	0	-2	0	-1
7	0	1	0	-1	-1
8	1	0	-2	-1	-1
9	1	1	0	-2	-1
10	0	1	-2	2	0
11	0	-1	2	0	0
12	1	-1	0	0	-2
13	0	1	0	0	-1
14	0	2	-2	-2	0
15	-1	0	2	2	-1
16	-2	0	0	1	2
17	0	0	1	-1	0
18	0	0	0	1	-1

Table 3.4 Differences in levels per choice set

Run	# options up	# options down	# levels up	# levels down	absolute difference
1	1	3	1	3	2
2	1	3	1	3	2
3	1	2	2	2	0
4	1	2	1	2	1
5	2	1	2	1	1
6	1	2	1	3	2
7	1	2	1	2	1
8	1	2	2	2	0
9	1	2	2	2	0
10	1	2	2	2	0
11	1	2	2	2	0
12	1	2	2	2	0
13	1	2	2	2	0
14	1	2	2	2	0
15	1	2	2	2	0
16	1	2	2	2	0
17	1	2	2	2	0
18	1	2	2	2	0

known for the attributes. This combination lead to the decision to create the second set by hand. It is shown in table 3.3(b). The differences between the levels is shown in table 3.3(c).

Table 3.4 shows for each choice set the change in levels and in options (attributes). For twelve questions, one attribute was lowered by one step, while two others were raised by one step or where one level was raised with two steps. The other six choice sets were raised or lowered unbalanced.

The number of questions with only on different attribute is zero, because it is already known that the influence on the utility function of all attributes is negative. So, an increase of an attribute results in a decrease of utility. Four choice sets differ on two attributes, nine choice sets differ on three attributes and in five questions four attributes were differed (table 3.5).

In a design without differences between attributes in choice sets, no information can be collected from the answers given by respondents. As a consequence, the levels have to

Table 3.5 Number of changed attributes

Changed attributes	number
1	0
2	4
3	9
4	5
5	0

be changed as much as possible. Not all with as much difference as possible between the attributes, but divided over one or two steps per attribute. This resulted in table 3.6. Travel time and travel costs are less important, so these are differed less. The other reason to do so, is to avoid making the choices to obvious. A last point of interest in the survey design is to check if no duplicates are introduced.

Table 3.6 Number of changed levels per attribute

	TT	MTC	N	S	AP
# total changed levels	11	10	17	17	15
# total changed alternatives	9	9	11	13	13

3.6.4 Sample size and population

The used sampling strategy will be the very common Simple Random Sampling (SRS) strategy (Louviere et al., 2006). In an SRS study, it is assumed that each member of the population has an equal change of being selected for the sample.
Because we do not want to draw conclusions about female professional drivers but about female drivers *or* professional drivers, the data can be used several times. This reduces the panel size. Instead of building a design with nine attributes, we now can have a design with five attributes and three questions added about the characteristics of the driver. The size of the sample can be calculated using equation 3.11.

$$n \geqq \frac{1-p}{rpa^2}\left(\Phi^{-1}\left(\frac{1+\alpha}{2}\right)\right)^2 \tag{3.11}$$

where:

Φ = cumulative normal distribution function
α = confidence level
a = accepted error
r = number of questions per participant
p = an estimate of the proportion falling into the group of interest
n = sample size

Table 3.7 Sample size with different error levels

(a) $p = 0.20$

Error level	Sample size
5%	342
6%	237
7%	175
8%	134
9%	106
10%	86

(b) $p = 0.33$

Error level	Sample size
5%	170
6%	118
7%	87
8%	67
9%	53
10%	43

(c) $p = 0.50$

Error level	Sample size
5%	86
6%	56
7%	43
8%	33
9%	26
10%	21

The smallest subgroup with a certain characteristic is about 20% (table 4.2), so $p = 0,2$. When $\alpha = 95\%$, Φ^{-1} would be $1,96$. The desired error level a is set to 5%, or $0,05$. As determined in paragraph 3.6.3, the number of questions r to be asked to respondents is 18. This results in a minimum desired sample size of $n = 342$. In theory, this number could be reduced by asking more questions to each participant or by increasing the error level. Because the number of questions is fixed to 18, the only way to handle a smaller sample size is to reduce the error level.
In table 3.7 the sample size for different error levels and sizes of groups of interest is given.

3.7 Survey lay-out

Survey setup The internet is used as survey medium, because in this way a lot of people can be reached, data can be canalized easily and it is a cheap way of conducting a SP experiment. The survey software LimeSurvey -an open source tool- is used for the questionnaire. It runs on the Apache web server and stores the data in a MySQL database. In LimeSurvey administrators can build their own survey with different types of questions and their own style sheets.
The software was placed on a server with adminstrator level access, in this way full control could be guaranteed over things like database access and backup strategies. It also gave the possibiliy to modify the software as much as needed to fit the requirements of this study.
The survey had an introduction to the study and the reason why the survey was conducted. The next step was to ask the respondents about their characteristics. After this set of questions one example question was asked. Based on the answer people gave, an explanation of the consequences was given to the respondents. Then, two sets of nine questions with a reminder of the type of driver they had chosen in the middle were asked. The entire survey can be found in appendix B.

The fonts The readability can greatly be influenced by the size and type of the fonts used for a text. Boyarski et al. (1998) showed that fonts designed for screen display are read faster and are higher rated than fonts designed for paper. Almost without exception sans serif fonts are preferred over serif fonts, as Bernhard et al. (2002) show. In that study, Verdana 10 was called the best font for online use. This font is used in the survey.

The coloring Hall and Hanna (2003) tried to determine the effects of the color combination of the font and the background. Their study indicated that 'positive texts' are preferred. Positive texts are texts where the background is light and the text is dark. Ling and van Schaik (2002) concluded that black text on a light blue background was the highest rated color combination. This combination was used in the survey.

3.8 Reducing complexity and avoid biases

Setting up a good survey is not without risk. Some possible risks are:

- People do not understand the questions or the difference between options in one question. If one does not know what the question is, the answer he gives cannot be used in the data analysis. To minimize this risk, all attributes in the questions are explained before the questions are asked and the answer on the example question is explained before the real SP questions are asked. Finally, during the survey, respondents can always get the explanation of an attribute by clicking on it in the survey.

- The questions can be too complex. This can be the case if too many attributes are different between two options or when too many options are included. Therefore in this survey the number of options reduced to two and are alternatives different in 2, 3, 4 and only sometimes in 5 ways.

- The so called 'repeated measurements problem' can bias the outcome of the survey. All simple methods for analyzing choice data require the assumption that the separate observations are independent. Because one respondent answers several questions, this assumption is broken and the outcome can be biased. This problem can be reduced by asking people to answer only a small number of questions. Another solution is to present the options in a random order. Therefore the questions are randomized within the two blocks of nine questions. Also the alternatives are presented in random order.

- The information can be less useful or invalid. Even if the answers are valid and the way they are processed is valid, it is still possible that the conclusions are useless, because the information people based their decisions on is invalid. Therefore, it is crucial to given the respondent the right information and to be sure people understand it correctly.

- People can recognize a pattern in the questions. This can lead to automated responses. This risk can be minimized by randomizing the questions, which was done in the survey.

- The complete set of respondents has to be a good representation of the entire set of drivers. It is possible that for all groups a valid conclusion can be drawn, but it is not possible to merge the results in one group. Knowledge about the composition of the entire group of drivers is important, just as it is important to know the composition of the sub-groups.

- The assumption that attributes are independent is might not be correct. This could result in wrong parameter estimations.

- Alternatives have to be realistic. This is tried to be achieved as explained in paragraph 3.6.2.

3.8.1 Results from the test surveys

As already mentioned, some test surveys were conducted before the final survey could be held. This was to determine the levels of the attributes, but also to test how the complexity of the questioning could be reduced.

The complexity bias is likely of such importance that it has to be reduced or removed entirely. One approach to do that is by introducing colors. The preferred levels are green, the middle levels are yellow and the undesirable levels are red. This was possible, because it is already known that the attributes change the utility in a negative relation.

Coloring of the attributes in the alternatives could be a good way of easing the decision making process. If one has to tell if the value of a certain attribute is high, medium or low, the answering is faster when colors are added. This is one of the outcomes of the test surveys held in advance of the final survey. Hence, the problem is that people do not focus on the column of an attribute, but focus on the row of an alternative. As a consequence, respondents tend to count the number of positive (green) and negative (red) colored attributes per alternative and compare the alternatives based on this. This is why the answering gets biased, even if people understand the values presented in the alternatives.

A second idea to ease the answering tested in an example survey was the idea of changing the font size of the attributes: the higher the value, the bigger the font size. Because not all attributes use the same scale, it becomes much harder to just count the big and small alternatives per row. The test survey resulted in a reduced, but not eliminated, bias. The respondents also claimed a reduced complexity.

In appendix A is an example question presented. As the outcome of a test survey shows, the coloring does help respondents to make the decision making process easier. But is it really an improvement to add colors? The problem is fundamental. A bias is added to reduce the effects of another bias. The exact effect of both biases on the decision making process is unknown and very hard to determine. The only thing known is that the coloring and the size reduce the complexity bias. As a consequence, the accuracy of the results of the study increases, but the reliability decreases. Therefore the choice is to introduce a new bias or to loose mathematical power. Here the decision is made not to introduce a new bias.

The answers of the SP test surveys is not analyzed thouroughly because the sample sizes were too small. The fact that respondents could tell how they made their decisions was clear enough to draw conclusions for this study.

Other questions which are answered by the second test survey are: 'Is there any difference in the valuation of the attributes if the questions are simpler compared to complex questions? Do people understand the values of the attributes better in case the values of the externality based attributes are translated to the number of casualties per year for the whole of the Netherlands?'

Both questions can be confirmed. Therefore, also these results lead to an adjustment of the design: from a mathematically driven design to a more practical design. The reason why this number is changed to numbers for the whole of the Netherlands is because people are more used to this type of information; casualty numbers are given per year, for example.

3.9 Maximum Likelihood Estimation

Maximum likelihood estimation (MLE) is the procedure of finding the value of one or more parameters for a given statistic that makes the known likelihood distribution a maximum.

The following explanation of MLE relies heavily on Bierlaire (2003).
The attributes x_{iq} are associated with individual q and alternative i. The probability for the model to reproduce the observed choice k is given by

$$P^k_{iq}(\beta, \alpha) = P_{iq}(\beta, \alpha, x^k_{iq}) \tag{3.12}$$

If a sample of K observations is available, the probability for the model to reproduce the whole sample is called the likelihood. This likelihood is given by

$$L^*(\beta, \alpha) = \prod_{k=1}^{K} P^k_{iq}(\beta, \alpha) \tag{3.13}$$

The maximum likelihood estimators $\hat{\beta}$ and $\hat{\alpha}$ are given by

$$(\hat{\beta}, \hat{\alpha}) = \arg\max_{\beta,\alpha} L(\beta, \alpha), \tag{3.14}$$

where

$$L(\beta, \alpha) = \ln L^*(\beta, \alpha) = \sum_{k=1}^{K} \ln P^k_{iq}(\beta, \alpha) \tag{3.15}$$

is the log-likelihood function.

MLE Software Several software packages are available to maximize the utility. NLOGIT, R and BIOGEME are the most well known. In this study, NLOGIT was not an option to use, because of the price of the software. In this study, MNL and MNP models are used, and because BIOGEME (Bierlaire, 2003, 2008) can handle both of these types of models, this package will be used in this study.

3.10 Test methods for discrete choice models

The first test which has to done is actually only a scan of the output of the estimation software. Are the signs of the attributes all in line with what was expected? What's the value of the alternative specific constants? What about the size of the β's in comparison to others? If these are in line with what was expected, the model provides at least reasonable results.

Several statistical tests are available to determine the significance of the results. The first one is the t-test, to check whether a particular estimate is significantly different from a constant. The critical value of a significance level of 5% would be ± 1.96. Another test is the ρ^2 goodness of fit test.

4
Results

This chapter presents the results of the survey. The chapter starts with an overview of the sample of respondents. Then the responses will be analyzed using a multinomial logit model. After this model, the multinomial probit model is used to determine if the drawbacks of the MNL model can be tackled. Finally, the valuation of the attributed by the different groups will be discussed.

4.1 Sample description

Table 4.1 Number of respondents

	Gender	Number
Started survey		232
Started, no answers		13
Stopped after characteristics		41
	Male	27
	Female	14
Inconsistent answers		11
	Male	11
	Female	0
Seriously inconsistent		0
Useful respondents		178
	Male	122
	Female	56

In total, 232 people started the survey. Of this group, 13 did not answer any question,

so no characteristics of this group could be determined. 41 people stopped the survey after answering the questions about driver characteristics. 27 of them were male, 14 female. This corresponds to the participation levels of fully cooperating respondents: approximately $\frac{1}{3}$ of the respondents was female, $\frac{2}{3}$ was male. So, 17% stopped answering at of right after the example question.
Another 14 respondents started answering the stated preference part, but stopped after the first set of nine questions. These responses are used in the estimation process.
11 persons were inconsistent in answering the stated preference part of the survey, all of them male.
Out of the initial 232 respondents, 178 respondents gave useful answers. 122 of them were male, 56 female.
The number of respondents for all categories can be found in table 4.1.

Table 4.2 shows the size of the groups within the sample and the entire population. This shows that there is a large discrepancy between the sample and the population: the number of young male with a low income is too big in comparison to the other groups. Especially older people with high incomes, both male and female, are underrepresented. A more comprehensive list can be found in appendix D.

Table 4.2 Characteristics of the sample and population

Characteristics		Respondents		Population*
		#	%	%
	Total	178	100	100
Gender	Male	122	68.5	58.4
	Female	56	31.5	41.6
Age	18-30	115	64.4	21.0
	31-45	37	20.8	27.0
	45+	26	14.6	52.0
Income	0 - 20.000	75	42.1	15
	20.000 - 45.000	75	42.1	38
	45.000+	28	15.8	47
Driver Type	Leasure	112	62.9	55
	Commuter	43	24.2	27
	Professional	23	12.9	18

*Source: Projectteam MON (2008)

The numbers in table 4.2 are based on the share in kilometers, not on the number of trips made per characteristic (Projectteam MON, 2008). So, if women account for 41,6% of the total number of kilometers, the number of female respondents in the sample has to be 41,6% too.

The respondents were invited by email, an online newsgroup of the University Twente and the online Fok! forum. Because the invitation by email was sent at the same time as the invitation to the forum and newgroup, no differences could be distinguished from the results between the origin of the respondents (email, newsgroup or forum). Also the response rate on the email invitation cannot be determined.

The self-gathered group invited by email leads to a bias, because the personal contacts are are part of the same social network as the researcher. As a result, too many people in this set from the eastern and northern parts of the Netherlands are included, which are less populated and congested as the western part. This group is also higher educated. To avoid familiarity with the subject, colleagues at the University of Twente were not invited.

The problem with the internet forum Fok! is the visitor sample. This group is younger, higher educated, and more often male than the average driver. This explains the main reason why young males with a low income are overrepresented in the survey sample. On the other hand, older drivers, professional drivers and drivers with an income over €45.000 are underrepresented. Attempts to compensate this discrepancy failed. For example, no permission was granted to put a link to the survey at the forum chauffeursforum.nl.

4.2 Choice models

The different modeling techniques are described in chapter 3. Two models are used. The first one is the logit model, the second one is the probit model. Because the probit model is actually a binary probit model (a multinomial probit model with two alternatives) the calculation time is very reasonable. This makes the mixed logit model redundant. For this reason, it is not used.

4.2.1 Multinomial Logit

To check if there was no significant difference between the two sets of options, a test was conducted with a MNL model which only had two alternative specific constants in the utility function. This lead to insignificant numbers with a very low ρ^2. This indicates a good choice set. The MNL model used is presented in appendix E.

As a first good model estimation, also the MNL model is used. The results are shown in table 4.3. This table shows the results of the maximum likelihood estimation with BIOGEME and the second model in appendix E. The fact that the alternative specific costant for the first alternative is always exact 0 is because in the estimation this value was fixed. Although the alternative specific constant of the second alternative is not zero, it is for all the subgroups insignificant.
The β's for all attributes are found to be negative. The t-test shown that all β's are significantly contributing to the utility of all groups of drivers. This indicates we have at least a reasonable model.

During the design stage of the survey, there were worries about the levels of noise, air pollution and safety, as described in paragraph 3.8.1. The β's found with this model make it very unlikely people just counted the levels. They did understand the differences.

4.2.2 Multinomial probit

To be able to use the MNL model, some unrealistic assumptions like the IIA have to be made. And because literature is not clear about the differences in the goodness of fit, the multinomial probit model is used as well. The third model in appendix E is the one used for these estimations. The outcome of the MNP model is not very different from the outcome of the MNL model. Only the ρ^2 values are slightly lower (table 4.4). Therefore, in the rest of the report, only the MNL outcomes will be used.

4.3 Attributes

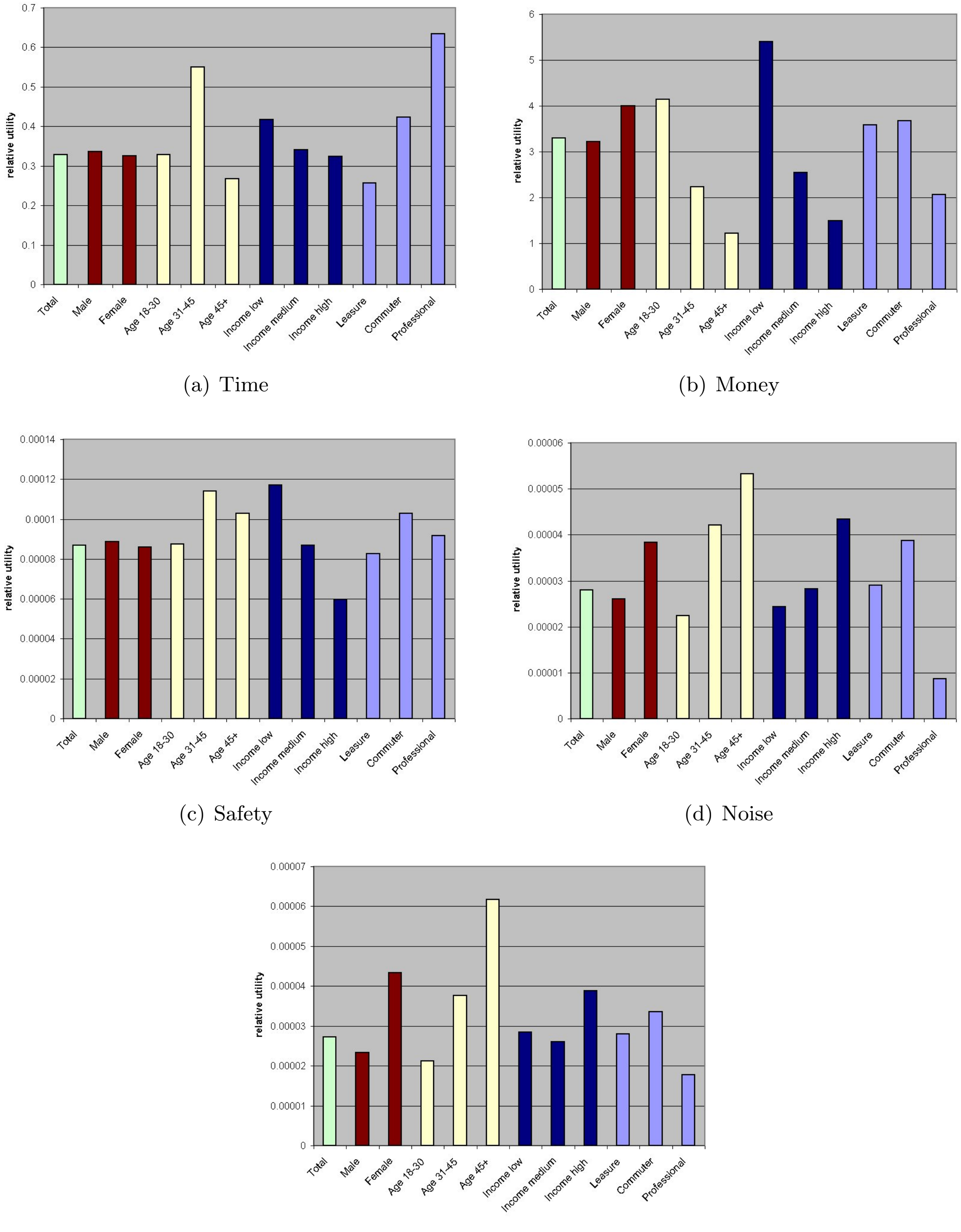
Figure 4.1 shows the importance of the five different attributes by driver group. In this figure, the results for the entire group (total) are not corrected for the sample size. But by analyzing separate groups this problem is largely solved.

To be able to compare the different betas in one figure, the original betas where multiplied by minus 1 (travel time), minus 10 (money) and minus 10.000 (noise, safety and air pollution) in figure 4.2. The most important attributes are travel time and travel costs. This is in line with findings in literature and what was expected. But also safety is quite important: roughly three times as important as air pollution or noise.

Travel time The importance of travel time for male and female drivers is about the same, no significant differences are found here.
Time is slightly more important for those with lower incomes than those with higher incomes. By looking at figure 4.1(a) one could imagine this is caused by the number of professional drivers who earn a low income. But as appendix D show, this could only be of small influence. It also does not correspond with the influence of money on the utility, as shown in figure 4.1(b). For professional drivers, time is more than twice as important as it is for leasure drivers. For commuters, time is about 1.5 times as important as it is for leasure drivers.

Money People with a low income do care about money much more than professional drivers. There is a clear correlation between age and income, but even after we only look at the middle income group, younger people value money higher than older people. This effect can be seen in figure 4.3. Also: women do care more about money than men. This effect is damped in figure 4.1(b) as a result of the overrepresentation of low income, young male drivers.

Noise The higher the income, the more important noise becomes. But also: the older, the more important noise. And income and age are correlated. In figure 4.4, people in the same income group value noise higher (as in: more negative) by the time they get older.
Remarkably is the difference between male and female drivers. While safety is not valued



(a) Time

(b) Money

(c) Safety

(d) Noise

(e) Air pollution

Figure 4.1 The importance of the attributes in the utility of a trip

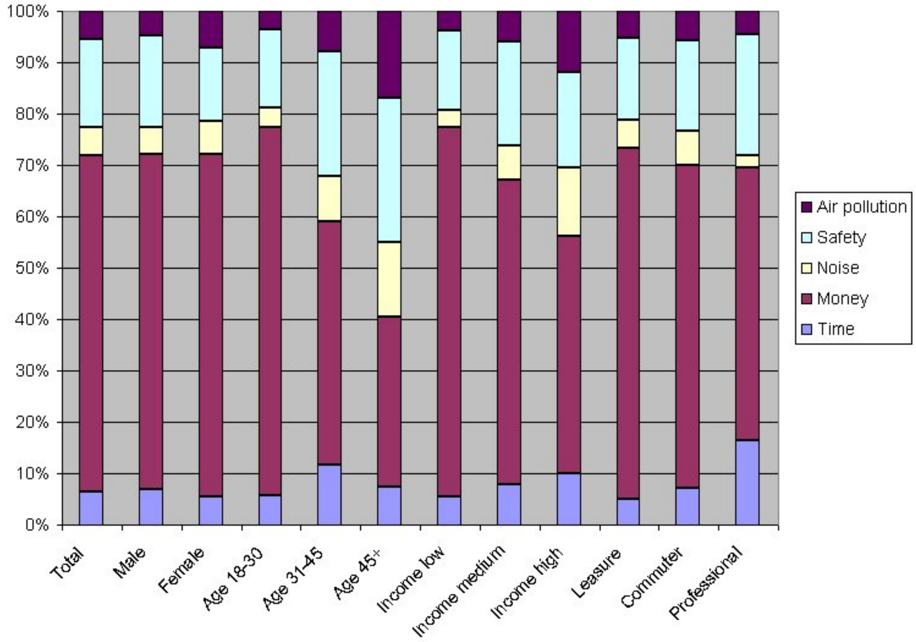


Figure 4.2 The importance as percentage of the utility

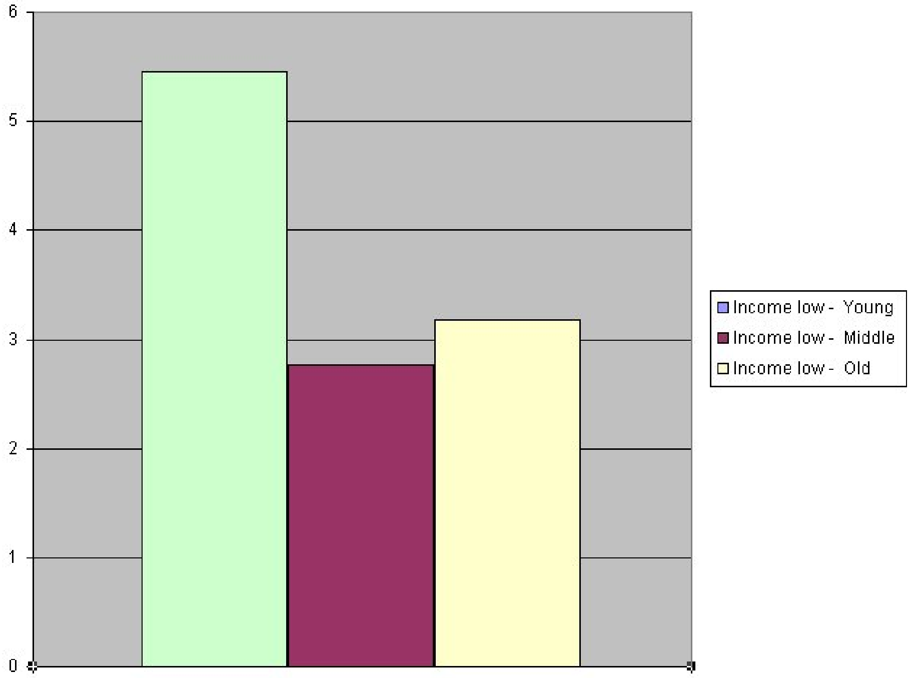


Figure 4.3 The valuation of money for people with a low income by age

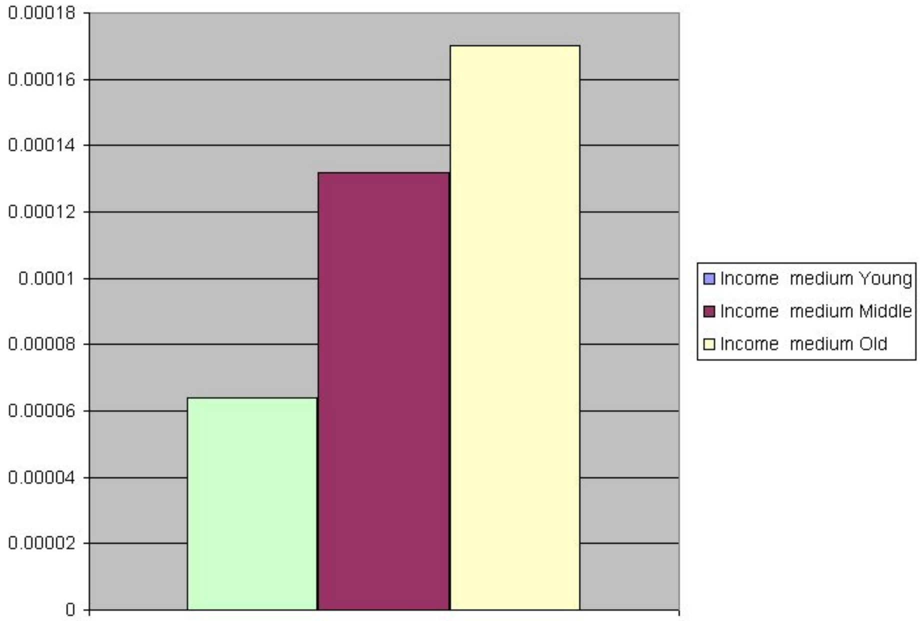


Figure 4.4 The influence of noise on the utility for people with a medium income by age

different from male, noise and air pollution are: noise is valued almost 50% higher while air pollution is valued amost 100% higher by women.

Safety The influence of safety on the utility is for the low income group about two times higher than for the high income group. This is remarkable, because this group doesn't value noise or air pollution higher than other groups. No subset has such a high variance within the subset as the income subset. An explanation of this is not found. Next to that, safety is for all other groups of equally importance.

Air pollution Just as for noise, women do care more about air pollution than men. And just like with noise, older people care more about air pollution than younger people. The fact that air pollution is three times as important for older drivers than it is for younger drivers can only be explained by the fact that older people suffer more often from pulmonary affections. Therefore they realize better what the effects of pulmonary affections are on the quality of life.
The reason why air pollution and noise are of higher importance to women than to men is partially caused by the overrepresentation of young drivers in the male sample, but also without this error, female drivers do care more about air pollution and noise than men.

4.4 Valuation of the attributes

Now the β values are determined for the five attributes in the systematic utility function, the valuation of these attributes can be compared easily. The valuation of the attributes is different from the influence of the attribute on the utility of the trip, because in the valuation money is incorporated. In this part, only the results from the MNL model will be used, because of the slightly better goodness of fit of the model in comparison to the MNP model.

Value of time Although it is not a goal of the study to determine the value of time, it is a very useful indicator how realistic people answered the questionnaire and how reliable the outcomes of the study are. In literature, a value of approximately €20 (Börjesson et al., 2007) to €25 per hour (Tseng and Verhoef, 2007) was found. In the latter study, the value of time was found using a stated prefence study. But especially the results found in the Börjesson et al. study are interesting, because the collected data is from a situation comparable to the one in this study. The €20 per hour is the value of time found for the road pricing system in Copenhagen, based on a revealed preference study.
In table 4.5 the valuation of time for the different groups in this study are shown. Initially, the findings seem to be too low. But the results are not that different from the Copenhagen situation. In that study, 30% did not have to pay themselves for the toll charged. So, this group tends to value time (which they have to invest by themselves) higher in relation to money (which is paid by the employer) in comparison to drivers who have to pay the toll themselves. Next to that, in de sample in this study are the low income group (€4.63/h) and the leasure drivers (€4.30/h) over represented and is the group of professional drivers (€18.41/h) under represented. This leads to a lower averaged value of time.

Value of noise, safety and air pollution The way the value of time is presented is pretty straight forward: €/hour. But the value of safety, noise or air pollution is somewhat harder to present and understand. In table 4.5 the first column per externality is based on the units used in the survey: money per trip and casualties annualy for the Netherlands. Because this is a rather complicated unit, the second column is converted to the value of one (average) casualty. This is done by multiplying the first column with the averga total number of trips per year per driver.

As mentioned in chapter 2, Bickel (2006) found WTP values of €19.000 for slight injured, €236.000 for severe injured and €1.782.000 for fataly wounded. No information could be retreaved about the relations between the number of severe and slight injured used in that study, so two estimations are used. This results in a willingness to pay of €152.000 to €316.080 for the population as a whole (table 4.6). Results found in this study, range from €102.943 to €410.752. Adjusted for the overrepresentation of young drivers, the willingness to pay found in this study is €164.325. This is within the range found by Bickel (2006).

One of the design problems mentioned in paragraph 3.6.2 is the difference between the levels in the survey of the externalities noise, safety and air pollution. If one does not understand the differences between the levels, they are assumed to value the externalities at a equal level. The values in table 4.5 show that people understand what was asked, because the differences in levels were smaller for safety, while the valuation is higher.

Young male drivers do care less about safety of others. This is partially consistent with the findings of Rizzi and Ortúzar (2003), because they also concluded thaht older drivers value safety higher. Next to that, they concluded that young male drivers in Chile did not want to pay at all for the safety of others. This is not consistent with the findings in the study: the influence of safety on the utility of trips for young male drivers is significant.

Value of money The valuation of money cannot be determined directly, but it is possible to derive an indication from the valuation of the other attributes. This is something different than what was shown in figure 4.1 and 4.2, because the total utility is not taken into account in those figures.
For example, all attributes are valued higher when respondents earn more. This could mean two things: or all of these attributes are valued higher when respondents earn more, or the attributes are valued about the same and the valuation of money differs between the groups. To get an indication of the differences in valuation, the variance between the groups and attributes is used. All the valuations per group are summed up and for the total group the index value is set to 100%. The results are shown in table 4.5. This table shows that older people care less about money than younger repondents and older respondents care less about money than professional drivers.

4.5 Reliability

The answers given by the 178 persons who filled out the survey are checked for consistent answering. This done by checking the answers on three sets of two questions. If somebody chooses in question 4 in favor of noise and safety (the second alternative, see appendix B for the questions), it is not consistent if he doesn't do that in question 2.

The tested sets are:

- Question 2 and question 4
- Question 3 and question 8
- Question 6 and question 8

In total eleven respondents answered inconsistent in one out of the three tested sets. No one answered inconsistent twice or even three times. Because mistakes can be made, one inconsistent answer is assumed still to be acceptable and therefore no respondents are removed from the results.

4.5.1 Error level

The total number of respondents is 178. At a confidence level of 95%, this results in an error level of 7% (see table 3.7).However, because the sample does not perfectly fit the population, the error level is slightly higher: after correction for the overrepresentation of young male with a low income, the error level for the entire sample is approximately 8%. For most sub-samples, the error level is also 8%. Two sub-sample have an error level of 7%: the mid-income group and the young drivers. The male sample has an error level of 5%.

4.5.2 Uncertainty

According to Manski (1977) four different sources of uncertainty can be distinguished:

- Unobserved individual characteristics (unobserved taste variation among individuals)
- Unobserved alternative attributes,
- Measurement errors and
- Instrumental variables.

It is clear that not all characteristics of drivers are taken into account. Other literature showed that for example household size does influence the valuation of externalities. How big this uncertainty is, cannot be determined, but it is likely some characteristics are important to take into account as well, while the ρ^2 still can be improved. Unobserved alternative attributes can be ruled out because of the character of the questions.

4.5.3 Goodness of fit

When the maximum likelihood estimation method is used to estimate the utility parameters in a MNL model,the log likelihood function evaluated at the mean of the estimated utility parameters is a useful criterion for assessing overall goodness of fit of the model Louviere et al. (2000). This test is known as the likelihood ratio test, abbreviated as LR.
The null hypothesis H_0 that the probability P_i of an individual choosing alternative i is independent of the value of the parameters used in the model:

$$P_i = \frac{1}{\sum_{j=1}^{J} e^{-(V_i - V_j)}} \tag{4.1}$$

The likelihood ratio test is useful, because it has the ability to test if subsets of the βs are significant.

To give some insight in the way the likelihood ratio test is conducted, a short explanation is given here. For a more comprehensive explanation, I would like to refer to Louviere et al. (2000).

$$L^* = \frac{\max L(\omega)}{\max L(\Omega)} \tag{4.2}$$

where L^* is the likelihood ratio, $\max L(\omega)$ is the maximum of the likelihood function in which M elements of the parameter space are constrained by the null hypothesis.

$L^*(0)$ is the value of the log likelihood evaluated such that the probability of choosing the ith alternative is exactly equal to the observed aggregate share in the sample of the ith alternative:

$$L^*(0) = \sum_{q=1}^{Q} \sum_{j=1}^{J} f_{jq} ln S_i \tag{4.3}$$

where S_i is the aggregate share in the sample of the ith alternative.
Let's define $L^*(\hat{\beta})$ as the maximized value of the log likelihood. The higher the explanatory power of the Xs in the utility function, the larger $L^*(\hat{\beta})$ will be in comparison to $L^*(0)$. To put this on an index scale, the likelihood ratio index is introduced:

$$\rho^2 = 1 - \frac{L^*(\hat{\beta})}{L^*(0)} \tag{4.4}$$

Both $L^*(0)$ and $L^*(\hat{\beta})$ are negative numbers. As a consequence, a bigger $L^*(\hat{\beta})$ is actually a number closer to zero. And the closer $L^*(\hat{\beta})$ is to zero, the higher ρ^2 and the better the fit. Values of ρ^2 between 0.2 and 0.4 are considered to represent a very good fit of the model.

$$\bar{\rho}^2 = 1 - \frac{\dfrac{L^*(\hat{\beta})}{\sum_{q=1}^{Q}(J_q - 1) - K}}{\dfrac{L^*(0)}{\sum_{q=1}^{Q}(J_q - 1)}} \tag{4.5}$$

According to the Neyman-Pearson lemma, the likelihood ratio test is the most powerful test for any significance levelNeyman and Pearson (1933).
where:

$$\begin{aligned} L^0 &= \text{Null Log Likelyhood for the model with all } \beta\text{'s being zero} \\ L^* &= \text{Final Log Likelyhood for the model with all optimal } \beta\text{'s} \\ K &= \text{degrees of freedom} \end{aligned}$$

If the values of ρ^2 are between 0.2 and 0.4 the model is indicated to have a very good fit.

A ρ^2 value was used to demonstrate the goodness of fit of the model. Like R^2, the ρ^2 value varies from 0.0 to 1.0 and measures the model's ability to account for variance in the dependent variable. The closer this value is to 1.0, the better the model represents the dataset (similar to R^2). ρ^2 is commonly used when measuring the goodness of fit of a model that has a discrete dependent variable, such as count data.

Rizzi and Ortúzar (2003) find ρ^2 values of approximately 0.16 in their best models. Contrary to the results found by Rizzi and Ortúzar, female drivers don't value safety higher in this study. But their study was not asking for safety of others, but for their own safety. And as they already concluded, that depends on how confident the driver is about his or her own skills.

4.6 The independence of irrelevant alternatives

Initially, it is assumed that the IIA assumption in MNL models is a major drawback. But it really the case in this study? Let's try to explain the IIA and the effects on the results in this study by looking at two examples and then translate it to this study. The first one is the example of the presidential elections in 2000 in the United States of America, given by Kropko (2008): “Very liberal voters sincerely would have preferred to vote for Ralph Nader over Al Gore, and for Gore over George W. Bush. However, strategic considerations moved many of these voters to vote for Gore in hopes of preventing the election of Bush. For these voters, for strategic reasons, the probability of voting for Gore was much higher than the probability of voting for Nader. But if Bush, an irrelevant alternative, is removed then they are much more likely to vote for Nader over Gore, thus violating the IIA assumption.”

The second example is the famous example of the red bus and the blue bus (McFadden, 1974). Wikipedia describes it in this way:
“Commuters initially face a decision between two modes of transportation: car and red bus. Suppose that a consumer chooses between these two options with equal probability, 0.5, so that the odds ratio equals 1. Now suppose a third mode, blue bus, is added. Assuming bus commuters do not care about the color of the bus, consumers are expected to choose between bus and car still with equal probability, so the probability of car is still 0.5, while the probabilities of each of the two bus types is 0.25. But IIA implies that this is not the case: for the odds ratio between car and red bus to be preserved, the new probabilities must be: car 0.33; red bus 0.33; blue bus 0.33.”

In these two examples, IIA is not violated in the same way. This becomes clear whe both examples are translated to the questions in this survey. First, the red bus/blue bus example. If we have the three alternatives

Alternative	levels				
	TT	MTC	N	S	AP
1	1	1	1	1	1
2	1	2	0	1	0
3	1	2	1	1	0

and alternative 1 and 2 are combined in one choice set. And if out of every three respondents two choose for alternative 1, the ratio alternative 1:alternative 2 is 2:1. The ratio alternative 1:alternative 3 will also be about 2:1, because alternative 1 and 3 are very similar. As a consequence, if alternative 1, 2 and 3 are combined in one choice set, the ratio would be something close to alternative 1:alternative 2:alternative 3 is 4:1:1. This violates the IIA, because these ratios are not the same.

But the US elections example is different. If that would be translated to this study, it would claim that some people would prefer alternative 2 over alternative 3 in case alternative 1 is added to the choice set, but the same respondent would prefer alternative 3 over alternative 2 in case alternative 1 is not part of the choice set. This is very unlikely.

As a result, the effects on the model are completely different. Because in case of the red bus/blue bus way of violating the IIA, only the magnitude of the different levels is hard to determine. This effect is reduced by asking a set of different questions, so the levels and attributes can be ordered and the size of the β's can be determined. In case of the US elections example, not only the magnitude of the attributes is hard to determine, also the sign of the β's cannot be determined that easy. Because of this, the IIA is not a big issue in this study, when using the MNL model.

Table 4.3 Estimated MNL model for the total of respondents and the subgroups

Variable	Total	Male	Female	Age (18-30)	Age (31-45)	Age (45+)	Income (0-20.000)	Income (20.000 - 45.000)	Income (45.000+)	Leasure	Commuter	Professional
ASC1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASC2	-0.0468	-0.0701	0.0445	-0.122	0.130	0.163	-0.172	-0.0575	0.204	-0.0692	0.0528	-0.152
t-test	-0.86	-1.13	0.37	-1.81	1.02	0.85	-1.93	-0.68	1.43	-0.98	0.49	-0.90
β_1	-0.328	-0.337	-0.325	-0.329	-0.550	-0.268	-0.417	-0.341	-0.324	-0.257	-0.424	-0.635
t-test	-6.10	-5.54	-2.71	-4.94	-4.40	-1.40	-4.64	-4.17	-2.32	-3.75	-3.93	-3.55
β_2	-3.30	-3.22	-4.00	-4.14	-2.24	-1.22	-5.40	-2.54	-1.50	-3.59	-3.68	-2.07
t-test	-8.49	-7.36	-4.41	-8.62	-2.44	-0.84	-8.03	-4.33	-1.45	-7.12	-4.62	-1.81
β_3	-2.80e-5	-2.60e-5	-3.84e-5	-2.24e-5	-4.21e-5	-5.32e-5	-2.43e-5	-2.83e-5	-4.34e-5	-2.90e-5	-3.88e-5	-8.72e-6
t-test	-7.68	-6.39	-4.46	-5.19	-4.71	-3.57	-4.31	-5.06	-4.17	-6.17	-5.11	-0.83
β_4	-8.70e-5	-8.86e-5	-8.59e-5	-8.76e-5	-1.14e-4	-1.03e-4	-1.17e-4	-8.69e-5	-5.98e-5	-8.28e-5	-1.03e-4	-9.18e-5
t-test	-12.91	-11.42	-6.14	-10.02	-7.22	-5.09	-9.14	-8.55	-3.87	-9.67	-7.62	-4.27
β_5	-2.72e-5	-2.34e-5	-4.34e-5	-2.12e-5	-3.76e-5	-6.17e-5	-2.85e-5	-2.60e-5	-3.89e-5	-2.80e-5	-3.35e-5	-1.78e-5
t-test	-7.03	-5.40	-4.84	-4.48	-4.17	-4.47	-4.44	-4.44	-3.80	-5.62	-4.27	-1.54
$L^*(0)$	-1479.869	-1134.000	-336.870	-981.496	-292.508	-205.865	-619.674	-623.139	-224.580	-925.351	-393.014	-161.503
$L^*(\hat{\beta})$	-1302.081	-1019.436	-273.329	-887.204	-227.164	-117.990	-530.309	-547.221	-181.071	-803.818	-324.204	-147.001
LR	355.577	247.127	127.081	188.585	130.688	172.750	178.729	151.836	87.017	243.066	137.620	29.005
ρ^2	0.120	0.108	0.189	0.096	0.223	0.427	0.144	0.122	0.194	0.131	0.175	0.090
Adj ρ^2	0.116	0.103	0.171	0.090	0.203	0.398	0.135	0.122	0.167	0.125	0.160	0.053
#	2135	1649	486	1416	422	297	894	899	324	1335	567	233

Table 4.4 Estimated MNP model for the total of respondents and the subgroups

Variable	Total	Male	Female	Age (18-30)	Age (31-45)	Age (45+)	Income (0-20.000)	Income (20.000 - 45.000)	Income (45.000+)	Leasure	Commuter	Professional
ASC1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASC2	-0.0276	-0.0412	0.0251	-0.0679	0.0646	0.0697	-0.0887	-0.0383	0.112	-0.0403	0.0295	-0.0834
t-test	-0.83	-1.09	0.35	-1.66	0.84	0.66	-1.67	-0.75	1.30	-0.95	0.45	-0.82
β_1	-0.195	-1.198	-0.188	-0.190	-0.327	-0.133	-0.229	-0.207	-0.186	-0.150	-0.252	-0.376
t-test	-6.05	-5.44	-2.68	-4.80	-4.41	-1.31	-4.40	-4.18	-2.23	-3.66	-3.93	-3.67
β_2	-1.99	-1.91	-2.35	-2.46	-1.41	-0.673	-3.10	-1.56	-0.863	-2.14	-2.22	-1.18
t-test	-8.72	-7.43	-4.59	-8.82	-2.63	-0.91	-8.28	-4.49	-1.45	-7.33	-4.85	-1.75
β_3	-1.71e-5	-1.58e-5	-2.26e-5	-1.38e-5	-2.49e-5	-2.95e-5	-1.48e-5	-1.73e-5	-2.54e-5	-1.79e-5	-2.32e-5	-5.31e-6
t-test	-7.83	-6.44	-4.59	-5.27	-4.85	-3.9	-4.37	-5.15	-4.28	-6.31	-5.24	-0.83
β_4	-5.26e-5	-5.32e-5	-5.15e-5	-5.19e-5	-6.78e-5	-5.64e-5	-6.70e-5	-5.31e-5	-3.49e-5	-4.97e-5	-6.18e-5	-5.43e-5
t-test	-13.59	-12.01	-6.41	-10.64	-7.50	-5.16	-9.78	-8.91	-3.79	-10.18	-8.02	-4.55
β_5	-1.63-5	-1.39e-5	-2.54e-5	-1.22e-5	-2.29e-5	-3.5e-5	-1.58e-5	-1.59e-5	-2.33e-5	-1.66e-5	-2.01e-5	-1.01e-5
t-test	-7.05	-5.35	-4.94	-4.35	-4.25	-4.76	-4.26	-4.50	-3.85	-5.63	-4.36	-1.47
$L^*(0)$	-1479.869	-1143.000	-336.870	-981.469	-292.508	-205.865	-619.674	-623.139	-224.580	-925.351	-393.014	-161.503
$L^*(\hat{\beta})$	-1302.415	-1019.717	-273.520	-887.774	-227.720	-119.128	-531.454	-547.277	-181.469	-804.106	-324.335	-147.142
LR	354.908	246.565	126.699	187.446	129.575	173.473	176.439	151.724	86.222	242.491	137.359	28.722
ρ^2	0.120	0.108	0.188	0.095	0.221	0.421	0.142	0.122	0.192	0.131	0.175	0.089
Adj ρ^2	0.116	0.103	0.170	0.089	0.201	0.392	0.133	0.112	0.165	0.125	0.159	0.052
#	2135	1649	486	1416	422	297	894	899	324	1335	567	233

Table 4.5 Valuation of the attributes

Group	Money	Time	Noise		Safety		Air Pollution	
	(%)	(€/hour)	(€/trip/mio cas)	(€/cas)	(€/trip/mio cas)	(€/cas)	(€/trip/mio cas)	(€/cas)
Total	100	5,96	8,48	41.255	26,36	128.241	8,24	40.088
Male	99	6,28	8,07	39.261	27,52	133.885	7,27	35.369
Female	104	4,88	9,60	46.704	21,48	104.500	10,85	52.785
Age (18-30)	135	4,77	5,41	26.320	21,16	102.943	5,12	24.909
Age (31-45)	48	14,73	18,79	91.413	50,89	247.580	16,79	81.683
Age (45+)	25	13,18	43,61	212.163	84,43	410.752	50,57	246.023
Income (0-20,000)	135	4,63	4,50	21.893	21,67	105.425	5,28	25.687
Income (20,000 - 45,000)	76	8,06	11,14	54.196	34,21	166.432	10,24	49.818
Income (45,000+)	45	12,96	28,93	140.744	39,87	193.968	25,93	126.149
Leasure	113	4,30	8,08	39.309	23,06	112.187	7,80	37.947
Commuter	89	6,91	10,54	51.277	27,99	136.171	9,10	44.272
Professional	64	18,41	4,21	20.482	44,35	215.763	8,60	41.839

Table 4.6 Willingness to pay per casualty for two divisions

(a)

Casualty type	Percentage (%)	Value (€)
Fatally injured%	4	1.782.000
Severe injured%	48	236.000
Slight injured%	48	19.000
Willingness to pay per casualty:		316.080

(b)

Casualty type	Percentage (%)	Value (€)
Fatally injured%	4	1.782.000
Severe injured%	32	236.000
Slight injured%	64	19.000
Willingness to pay per casualty:		152.000

5 Discussion

5.1 The survey

During the survey, respondents are reminded two times what type of driver they selected in the beginning of the survey. Some respondents reported this to be a little annoying. But the fact that a relative small number of people stopped the survey after this break in the questioning indicates the annoyance about it was not that big. In this case it seems to be more important that people answer with the right driver type in mind than a small number of respondents who only answers half of the questions.

The fact that only a few people stopped answering during the survey, is also indication that people did understand the questions. Respondents can react in four possible ways. The first possibility is respondents stop filling out the survey before all questions are answered. This happened in 7% of the cases. Not filling out at all the stated preference part of the survey is another possibility. This happened in 17% of the cases. A third possibility is to fill out the questionnaire, but because it is experienced to be too complex, respondents just choose the answers at random. As mentioned in paragraph 4.5, no evidence is found this happened. The fourth possibility is the desired one: people did understand the questions and filled out the entire survey.
The 17% who did not filled out the stated preference part of the survey can lead to biased results. If it is assumed to a large extend this group stopped because of the complexity of the questions, the sample used in the maximum likelihood estimation contains too little people who are not willing or capable to think about the external costs when making a route choice. This leads to estimations of the valuation of attributes which are too high.

The combination of the possibility to stop the answering and the lack of evidence about random answering, supports the design choice to reduce the presentation of the attributes to *casualties*. In the stated preference questions all three externality based attributes are expressed in *casualties*. However, this is a serious drawback, because the group of casualties is build up out of those who only needed medical aid and fatalities. It is obvious people do not value all levels of medical aid the same, let alone fatally injured.

5.2 Sample and population

The problem with the relative high number of young male with a low income in the sample and the small group of people who are older than 45 with a high income is a result of the way the respondents were approached. Initially the numbers about the internet access of the population looked promising, but afterwards it can be concluded that to get a representative group of respondents, an online survey still has it's drawbacks as long as this type of surveys is not held within a particular group. This could be avoided by contacting a company who can guarantee a certain number of respondents per group or to put more effort in selection certain online communities all of them with their own user base.

Another bias not discussed before is inherent to every survey and to this questionnaire in special. The type of person willing to fill out a survey is likely to be more altruistic than the average Dutchman, because the person is spending time on something he is not gaining from in any direct way. To a large extent, the valuation of the attributes is based on altruism. This is something which is hard to tackle, but maybe this could be done by paying people or by raffle some goodies in exchange.

5.3 Theoretical and practical relevance

This study does add knowledge about the way drivers value externality based attributes in the utility function. As far as known by the author, this study makes it possible for the first time to draw conclusions about the willingness of drivers to carry all the costs which arise from their decisions.

The results are found to be logical. The results of the tests also show that the outcomes are statistically correct. And the results are consistent with earlier work. For example, the value of time found in this research is close to revealed preference data showed in Denmark.

What do the results mean for future work on the implementation of a road pricing system in the Netherlands? It shows that there is a realistic method which can be implemented in a road pricing system and what can lead to an increasing societal welfare, without the economical drawbacks of a system only based on the price of a certain route. It can even be implemented without a road pricing system, as long as it gives information about the effects drivers cause. This information is enough to change the behavior of the majority of the drivers.

The fact that the different groups do not only value the attributes time, noise safety and air pollution differently but also that they value money differently has consequences for the way road pricing systems have to be implementend. Assumed the goal of the system is to internalize one or more externality and create a fair price for road use. If, for example, a road pricing system is introduced to reduce congestion, the assumption is often made that professional drivers value time higher than others. But what these results show, is that they also value money higher than older drivers. As a result, the effect of raised toll levels will not be what was expected when the system was implemented in an area where many older drivers are on the road. This shows that the implementation of road pricing systems is something which has to be prepared well in advance, while the local user group can be of great influence on the effect.

It is assumed that the importance of air pollution is better understood by older drivers because they suffer more from pulmonary affections. It is important to be sure about this, because if this is really the case, it supports the idea that people are really willing to change behavior, as long as they know what the consequences are.

6 Conclusion and recommendations

6.1 Conclusion

Traffic causes a lot of external costs. Drivers seem to realize this. They are willing to spend more on their trips, both in terms of money as in time, to reduce these external effects. As a result, the externalities noise, air pollution and safety are significantly influencing the utility of road users.

This study shows the externalities travel time, monetary travel costs, noise, safety and air pollution can be determined relatively precise by using a stated preference study. The outcomes of the study do not entirely match the outcomes of other studies, but clearly there are similarities. For example, in this study, female driver do care more about the external costs than male drivers, but for safety, the difference is neglectable. While in an existing study women do care more about safety as well. Also the valuation of travel time seems to be realistic in comparison to work done in Denmark. The willingness to pay for the safety of others is close to the willingness to pay for safety (the driver included) found in previous work.

Young people tend to care 40% more about money than older people, even when the differences in incomes are taken into account. At the same time, older drivers value noise and air pollution much higher than younger people: two to three times higher.

The IIA assumption is broken for the MNL model. But as this report shows, the IIA is not a major drawback because of the way the IIA is broken. The MNP model doesn't give a better fit than the MNL model. Both models do give a reasonable goodness of fit.

The sample is not strictly random: the group of young male drivers is overrepresented, while the group of respondents of older drivers, females and those with a high income are too small.

Although the valuation of the externalities is known now, it is still unknown how much the effect on the societal welfare will be. This has mainly to do with the availability of alternatives for the drivers. If two routes hardly differ in terms of external costs, there is no reason for the driver to change his behavior. This depends on the network characteristics.

6.2 Recommendations

The results in this study look promising. It is worth to study how the necessary information can be collected, stored and distributed to the drivers, to create a real alternative to road pricing systems.

Another recommendation is to study the sustainability of the findings in this study. Respondents were new to the idea of receiving information about the effect they have on others. It is very well possible that after the implementation of an information system people initially change their behavior, but after a while return to their old habits again. Every day spending an extra three minutes and paying half a euro extra are felt every day, while the information about the effects on others are less impressive if heard many times. It is unknown if this effect exists and if so, how it will influence the valuation of the attributes on the long term.

The goodness of fit for the entire sample can be increased if the number of respondents is increased, so the utility function can be expanded by the characteristics of of the drivers. It can also be increased by defining more characteristics of the driver and include them in the way characteristics are included now. Two of these possible characteristics are household size and level of education. To retain a reasonable error level, the number of respondents have to be increased as well.

No second order models are tested. It is recommended to determine which attributes are possible non-linear and to estimate a second order model to increase the goodness of fit even further. The data collected in this study can be used for this estimation, because the choise sets are designed for both first and second order model estimation.

To overcome the shortcoming of the specification of *casualties* in the questionnaire, it is recommended to extend this study with a questionnaire which distinguishes different types of casualties. To avoid too complex questions, the focus can be on one type per questionnaire. By designing several questionnaires, the complexity bias can be avoided.

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Appendices

A
Test surveys

Testlijst

Deze lijst is opgesteld voor onderzoek naar het gedrag van bestuurders

0% 100%

Nederlands

Complex-grijs

*Welke van de onderstaande opties zou u kiezen?

Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
20 min.	€ 3,75	100 pers.	1/1000 ste	600 pers.
22 min.	€ 4,25	150 pers.	3/1000 ste	800 pers.

*Welke van de onderstaande opties zou u kiezen?

Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
20 min.	€ 4,00	50 pers.	3/1000 ste	600 pers.
22 min.	€ 3,75	100 pers.	1/1000 ste	800 pers.

Testlijst

Deze lijst is opgesteld voor onderzoek naar het gedrag van bestuurders

0% 100%

Nederlands

Complex-kleur

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
○	20 min.	€ 3,75	150 pers.	3/1000 ste	600 pers.
○	18 min.	€ 4,00	100 pers.	1/1000 ste	400 pers.

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
○	20 min.	€ 4,00	100 pers.	1/1000 ste	600 pers.
○	18 min.	€ 4,25	50 pers.	5/1000ste	400 pers.

Testlijst 2.0

Deze lijst is opgesteld voor onderzoek naar het gedrag van bestuurders

0% 100%

Complex--size

*Welke van de onderstaande opties zou u kiezen?

Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
20 min.	€ 4,00	150 pers.	5/1000 ste	400 pers.
18 min.	€ 4,25	100 pers.	3/1000 ste	800 pers.

*Welke van de onderstaande opties zou u kiezen?

Reistijd	Kosten	Mensen die geluidsoverlast ondervinden	Kans dat u anderen letsel toebrengt	Mensen die last hebben van uw luchtvervuiling
22 min.	€ 4,25	100 pers.	5/1000 ste	800 pers.
18min.	€ 3,75	50 pers.	3/1000 ste	600 pers.

B
Survey


Vragenlijst waardering externaliteiten

Er zijn 23 vragen in deze vragenlijst.

Een opmerking over uw privacy
Deze vragenlijst is anoniem.
Privacy statement: Deze vragenlijst is anoniem. De bewaarde antwoorden bevatten geen identiteitsgegevens tenzij u deze bij een bepaalde vraag hebt ingevuld. Indien u via een toegangscode deelneemt kunnen wij u verzekeren dat deze niet wordt bewaard in combinatie met uw antwoorden maar wel is opgeslagen in een aparte tabel. De tabel met toegangscodes wordt gebruikt om na te kijken of een vragenlijst reeds voor de betreffende toegangscode is ingevuld. Er is geen enkele manier om de codes te koppelen aan de antwoorden.

Laad onvoltooide vragenlijst | Volgende >> | [Afbreken en antwoorden verwijderen]

Vragenlijst waardering externaliteiten

0% 100%

Inleiding

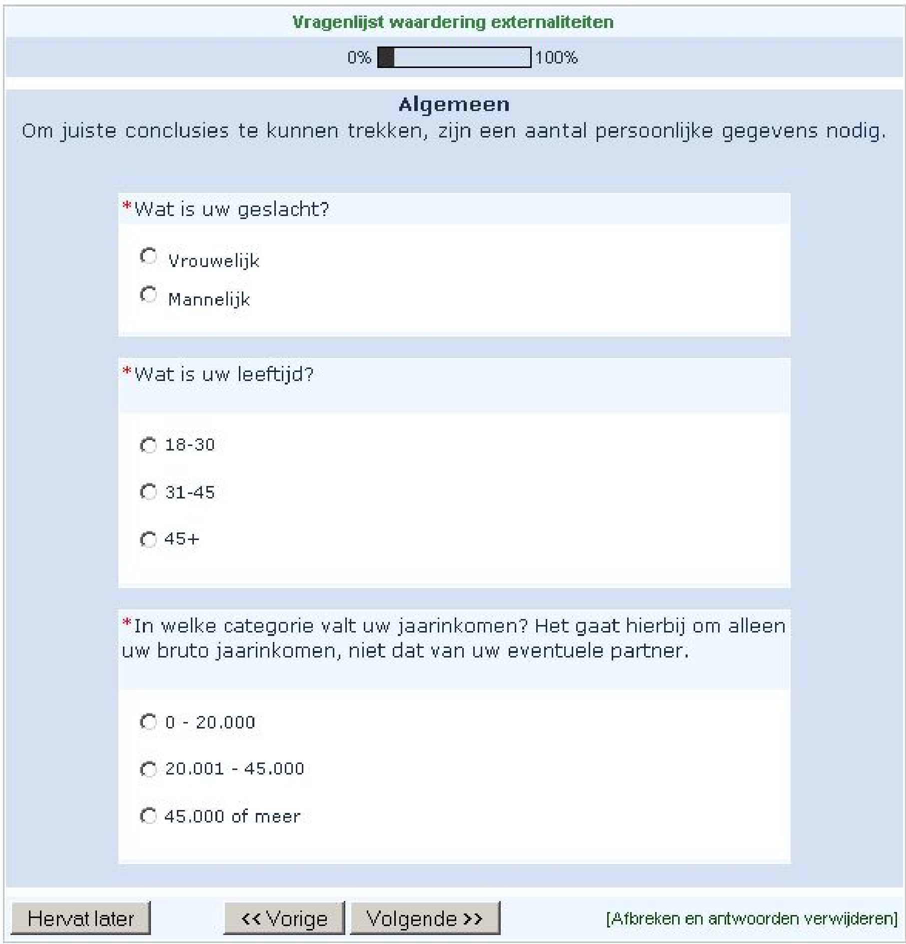
Er is weinig bekend over de mate waarin mensen hun gedrag in het verkeer willen aanpassen om de gevolgen voor medeweggebruikers en omwonenden te verkleinen. Om hier meer inzicht in te krijgen, is de nu volgende vragenlijst opgesteld. De vragenlijst is onderdeel van onderzoek dat wordt verricht aan de Universiteit Twente.

Er volgen nu eerst vier vragen over uzelf , daarna volgen er achttien vragen die gaan over een denkbeeldige situatie, waarbij er steeds uit twee opties gekozen moet worden. De beantwoording is volledig anoniem, er worden geen gegevens opgeslagen anders dan die u zelf heeft ingevuld en de antwoorden zullen niet gebruik worden voor andere doeleinden dan dit onderzoek. De resultaten zijn na de afronding van het onderzoek vrij op te vragen bij de Universiteit Twente.

Het invullen van de volledige vragenlijst zal ongeveer tien minuten van uw tijd vragen, ik wil u verzoeken deze lijst zorgvuldig in te vullen.

Universiteit Twente
de ondernemende universiteit

Hervat later | << Vorige | Volgende >> | [Afbreken en antwoorden verwijderen]


Vragenlijst waardering externaliteiten

0% 100%

Algemeen

Om juiste conclusies te kunnen trekken, zijn een aantal persoonlijke gegevens nodig.

*Wat is uw geslacht?

- Vrouwelijk
- Mannelijk

*Wat is uw leeftijd?

- 18-30
- 31-45
- 45+

*In welke categorie valt uw jaarinkomen? Het gaat hierbij om alleen uw bruto jaarinkomen, niet dat van uw eventuele partner.

- 0 - 20.000
- 20.001 - 45.000
- 45.000 of meer

Hervat later | << Vorige | Volgende >> | [Afbreken en antwoorden verwijderen]


Vragenlijst waardering externaliteiten
0%
100%
Type chauffeur
*Tot welke groep bestuurders behoort u?
LET OP!
U kunt zichzelf slechts tot 1 groep rekenen. De overige vragen in de vragenlijst moet u beantwoorden vanuit de gedachte tot die groep te behoren.
Vrijetijdsbesteding
Forens
Zakelijk rijder (chauffeur, b.v.)
Hervat later
<< Vorige
Volgende >>
[Afbreken en antwoorden verwijderen]

Vragenlijst waardering externaliteiten

0% 100%

Uitleg attributen

In de vragen wordt u telkens verzocht een keuze te maken tussen twee opties. Deze opties zijn opgebouwd uit vijf verschillende eigenschappen (attributen). Deze eigenschappen zijn weer onderverdeeld in drie niveaus.

De eigenschappen zijn:

- Geluidsoverlast
- Onveiligheid
- Luchtvervuiling
- Reistijd
- Kosten

Onderstaande uitleg is per eigenschap ook tijdens de enquête op te vragen door op de eigenschap te klikken

GELUIDSOVERLAST
Hiermee wordt de extra overlast door uw aanwezigheid bedoeld. Op een drukke weg is uw aandeel gering, in de nacht op een rustige weg is uw aandeel groter. Door drukke gebieden is de overlast door u groter dan bij routes die door dunbevolkt gebied komen.

Geluidsoverlast wordt in Nedeland vaak als erg vervelend ervaren (veel meer mensen geven aan last te hebben van geluid van verkeer dan van de uitstoot van verkeer), maar zelden wordt het gezien als doodsoorzaak. Toch valt drie procent van de hartaanvallen te herleiden op verkeerslawaai. Daarnaast zijn het vooral slaapstoornissen die de medische gevolgen vormen van verkeersgeluid. Geluid kent daarnaast een groot 'ergernisgehalte'. Deze drie factoren tezamen zijn uitgewerkt in een aantal slachtoffers.

De waarden voor geluidsoverlast in de volgende vragen zullen zijn:
- Laag: 10.000 slachtoffers
- Midden: 25.000 slachtoffers
- Hoog: 40.000 slachtoffers

Vragenlijst waardering externaliteiten

0% 100%

Voorbeeldvraag

*In de nu volgende set vragen verschillen de opties op ten minste twee en maximaal vier punten van elkaar. Om duidelijk te maken hoe de vragen werken, volgt hier een voorbeeldvraag. Denkt u eraan dat u de vragen dient te beantwoorden met in gedachte het type chauffeur dat u hebt gekozen.

VOORBEELDVRAAG:

Welke van de onderstaande opties zou u kiezen?

Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
20 min.	€ 4,00	25.000	25.000	40.000
22 min.	€ 4,25	25.000	15.000	20.000

Hervat later << Vorige Volgende >> [Afbreken en antwoorden verwijderen]


Vragenlijst waardering externaliteiten
0%
100%
Uitleg antwoord
U heeft gekozen voor de optie waarbij u EN sneller (2 minuten) EN goedkoper (25 cent) de plaats van bestemming kunt bereiken. Het gevolg is wel dat als iedereen in Nederland al zijn routekeuzes een jaar lang op deze manier zou maken, er 10.000 zwaar gewonden en 200 doden meer zouden vallen. Ook zouden er jaarlijks 20.000 mensen meer het slachtoffer zijn van luchtwegaandoeningen als gevolg van de uitstoot van het verkeer.
Hervat later
<< Vorige
Volgende >>
[Afbreken en antwoorden verwijderen]


Vragenlijst waardering externaliteiten
0%
100%
Herinnering: type chauffeur
U heeft aangegeven de meeste ritten met de auto te maken als FORENS. U wordt verzocht de ALLE volgende vragen te beantwoorden met deze keuze in gedachte.
Hervat later
<< Vorige
Volgende >>
[Afbreken en antwoorden verwijderen]

Vragenlijst waardering externaliteiten

0% 100%

Vragenlijst-deel1

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	20 min.	€ 4,00	10.000	25.000	40.000
○	20 min.	€ 3,75	10.000	35.000	60.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	18 min.	€ 4,00	10.000	25.000	60.000
○	22 min.	€ 4,00	10.000	15.000	40.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	18 min.	€ 4,25	40.000	15.000	40.000
○	20 min.	€ 4,25	10.000	15.000	20.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	18 min.	€ 4,25	25.000	35.000	20.000
○	18 min.	€ 4,00	40.000	35.000	40.000


Vragenlijst waardering externaliteiten
0%
100%
Herinnering
Ter herinnering: u heeft aangegeven dat u de meeste ritten maakt als FORENS.
Hervat later
<< Vorige
Volgende >>
[Afbreken en antwoorden verwijderen]

Vragenlijst waardering externaliteiten

0% 100%

Vragenlijst-deel2

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	22 min.	€ 4,00	25.000	15.000	40.000
○	22 min.	€ 3,75	25.000	15.000	60.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	20 min.	€ 4,25	25.000	25.000	20.000
○	22 min.	€ 4,00	25.000	25.000	20.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	20 min.	€ 4,00	40.000	25.000	20.000
○	20 min.	€ 4,25	10.000	25.000	20.000

*Welke van de onderstaande opties zou u kiezen?

	Reistijd	Kosten	Geluidsoverlast	Onveiligheid	Luchtvervuiling
○	22 min.	€ 4,00	25.000	15.000	20.000
○	20 min.	€ 4,25	25.000	15.000	60.000


Dank u
Uw antwoorden zijn bewaard.
Sluit dit venster

C Explanation

In de vragen wordt u telkens verzocht een keuze te maken tussen twee opties. Deze opties zijn opgebouwd uit vijf verschillende eigenschappen (attributen). Deze eigenschappen zijn weer onderverdeeld in drie niveaus. De eigenschappen zijn:

- Geluidsoverlast
- Onveiligheid
- Luchtvervuiling
- Reistijd
- Kosten

Onderstaande uitleg is per eigenschap ook tijdens de enquête op te vragen door op de eigenschap te klikken

Geluidsoverlast

Hiermee wordt de extra overlast door uw aanwezigheid op de weg bedoeld. Zo is op een drukke weg uw aandeel in de totale overlast gering, maar is dat in de nacht op een rustige weg groter. Door drukke gebieden is de overlast door u groter dan bij routes die door dunbevolkt gebied komen.

Geluidsoverlast wordt in Nedeland vaak als erg vervelend ervaren (veel meer mensen geven aan last te hebben van geluid van verkeer dan van de uitstoot van verkeer), maar zelden wordt het gezien als doodsoorzaak. Toch valt drie procent van de hartaanvallen te herleiden op verkeerslawaai. Daarnaast zijn het vooral slaapstoornissen die de medische gevolgen vormen van verkeersgeluid. Geluid kent daarnaast een groot 'ergernisgehalte'.

Deze drie factoren tezamen zijn uitgewerkt in een aantal slachtoffers.

De waarden voor geluidsoverlast in de volgende vragen zullen zijn:

- Laag: 10.000 slachtoffers
- Midden: 25.000 slachtoffers
- Hoog: 40.000 slachtoffers

Onveiligheid

Het gaat hier alleen om de veiligheid van medeweggebruikers, niet om uw eigen veiligheid. De veiligheid wordt uitgedrukt in de kans op letsel. Een kleiner getal wil dus zeggen dat de kans dat u betrokken bent bij een ongeval waar u anderen letsel toebrengt kleiner is.
In Nederland kwamen de laatste jaren ongever 800 mensen per jaar om het leven in het verkeer. Daarnaast moesten nog eens ongeveer 20.000 mensen per jaar in een ziekenhuis worden behandeld. Veel van deze verkeersslachtoffers zijn te voorkomen door meer gebruik te maken van veilige wegen. Het gaat over getallen om betrokken te raken bij een ongeval waarbij ANDEREN, dus NIET JIJ, gewond raken of komen te overlijden.

Het aantal slachtoffers (doden en zwaar gewonden) tezamen geven voor de volgende vragen:

- Laag: 15.000 slachtoffers
- Midden: 25.000 slachtoffers
- Hoog: 35.000 slachtoffers

Luchtvervuiling

Ook hier gaat het om de lokale gevolgen van uw keuze. Als er meer mensen langs uw route wonen of leven, dan neemt het aantal mensen dat aan uw vervuiling wordt blootgesteld toe, vervuiling die over langere perioden kan leiden tot gezondheidsproblemen. Het gaat hier alleen om fijnstof en stikstof. CO_2 maakt hier geen onderdeel van uit.

Eerder studies hebben aangetoond dat de uitstoot van verkeer grote invloed heeft op de gezondheid van mensen. Zo liggen luchtweggerelateerde ziekhuisopnamen in vervuilde gebieden bijna 20% hoger dan in verkeers- en industrieluwe gebieden. Een andere studie liet een verzesvoudiging van kinderkanker zien bij kinderen die langs een drukke verkeersader opgroeien. Vanuit deze gegevens en het totaal aantal gereden kilometers, zijn de volgende niveaus voor luchtvervuiling bepaald.

- Laag: 20.000 slachtoffers
- Midden: 40.000 slachtoffers

- Hoog: 60.000 slachtoffers

Hierbij zijn slachtoffers mensen komen te overlijden of chronisch ziek worden ten gevolge van de uitstoot van verkeer.

Reistijd

Het gaat hier om de reistijd die u nodig zult hebben om de route af te leggen. De reistijd wordt weergegeven in minuten: 18, 20 of 22 minuten.

Kosten

Het gaat hier om de kosten die u (of uw bedrijf/werkgever) zult maken om de route af te leggen. Het gaat hier om kosten direct gerelateerd aan het gebruik van de auto: brandstof en slijtage aan de auto. De bedragen verschillen tussen €3,75, €4,00 en €4,25 euro.

LET OP!

Alle bovenstaande getallen zijn afgeleiden van werkelijke en reeele getallen, maar hoeven geen realisitsche waarden voor de reductie van slachtoffers in te houden. U dient aan te nemen dat als u een bepaalde keuze maakt, de gevolgen daarvan op grote schaal zo zullen zijn als weergegeven in de vragen.

D Respondents

Table D.1 Number of male respondents

Sample (#)	Age	Sample (#)	Income	Sample (#)	Driver type	Sample (#)
122	18-30	77	0-20.000	51	Leasure	37
					Commuter	7
					Professional	7
			20.000-45.000	23	Leasure	12
					Commuter	8
					Professional	3
			45.000+	3	Leasure	2
					Commuter	1
					Professional	0
	31-45	29	0-20.000	2	Leasure	1
					Commuter	0
					Professional	1
			20.000-45.000	19	Leasure	7
					Commuter	7
					Professional	5
			45.000+	8	Leasure	5
					Commuter	2
					Professional	1
	45+	16	0-20.000	2	Leasure	2
					Commuter	0
					Professional	0
			20.000-45.000	6	Leasure	3
					Commuter	3
					Professional	0
			45.000+	8	Leasure	5
					Commuter	1
					Professional	2

Table D.2 Number of female respondents

Sample (#)	Age	Sample (#)	Income	Sample (#)	Driver type	Sample (#)
56	18-30	41	0-20.000	16	Leasure	13
					Commuter	2
					Professional	1
			20.000-45.000	19	Leasure	12
					Commuter	7
					Professional	0
			45.000+	6	Leasure	2
					Commuter	2
					Professional	2
	31-45	5	0-20.000	1	Leasure	1
					Commuter	0
					Professional	0
			20.000-45.000	3	Leasure	2
					Commuter	1
					Professional	0
			45.000+	1	Leasure	0
					Commuter	0
					Professional	1
	45+	10	0-20.000	4	Leasure	2
					Commuter	1
					Professional	1
			20.000-45.000	5	Leasure	4
					Commuter	1
					Professional	0
			45.000+	1	Leasure	1
					Commuter	0
					Professional	0

E

BIOGEME model files

```
// File Gertjan-MNL.mod

[ModelDescription]
"Example of a model specification file for multinomial logit"
"This file contains the minimum model description needed by BIOGEME"
"Note that ASC1 is constrained to 0.0 and will not be estimated"

[Choice]
Choice

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

[Utilities]
// Id Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 + )
  1   Alt1   av1   ASC1 * one
  2   Alt2   av2   ASC2 * one

[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1
av1 = 1
av2 = 1
Weight = 1

[Mu]
1.0 0.0 1.0 1

[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid keywords
//
$MNL
```

```
// File Gertjan-MNL.mod

[ModelDescription]
"Example of a model specification file for multinomial logit"
"This file contains the minimum model description needed by BIOGEME"
"Note that ASC1 is constrained to 0.0 and will not be estimated"

[Choice]
Choice

[Beta]
// Name Value  LowerBound UpperBound  status (0=variable, 1=fixed)
//ASC1     10         -10000         10000       1
//ASC2     0         -10000         10000       0
Beta1     0         -10000         10000       0
Beta2     0         -10000         10000       0
Beta3     0         -10000         10000       0
Beta4     0         -10000         10000       0
Beta5     0         -10000         10000       0

[Utilities]
// Id Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 +)
  1   Alt1   av1   Beta1 * TT1 + Beta2 * MTC1 + Beta3 * AP1
+ Beta4 * S1 + Beta5 * N1
  2   Alt2   av2   Beta1 * TT2 + Beta2 * MTC2 + Beta3 * AP2
+ Beta4 * S2 + Beta5 * N2

[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1
av1 = 1
av2 = 1
Weight = 1

[Mu]
1.0 0.0 1.0 1

[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid keywords
//
$MNL
```

```
// File Gertjan-BinaryProbit.mod

[ModelDescription]
"A simple Binary Probit model"
"This file contains the minimum model description needed by BIOGEME"
"Note that ASC1 is constrained to 0.0 and will not be estimated"

[Choice]
Choice

[Beta]
// Name Value  LowerBound UpperBound  status (0=variable, 1=fixed)
ASC1     0         -10000         10000       0
ASC2     0         -10000         10000       0
Beta1     0         -10000         10000       0
Beta2     0         -10000         10000       0
Beta3     0         -10000         10000       0
Beta4     0         -10000         10000       0
Beta5     0         -10000         10000       0

[Utilities]
// Id Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 +)
  1   Alt1   av1   ASC1 * one + Beta1 * TT1
+ Beta2 * MTC1 + Beta3 * AP1
+ Beta4 * S1 + Beta5 * N1
  2   Alt2   av2   ASC2 * one + Beta1 * TT2
+ Beta2 * MTC2 + Beta3 * AP2
+ Beta4 * S2 + Beta5 * N2

[Draws]
50

[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1
av1 = 1
av2 = 1
Weight = 1

[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid keywords
//
$BP
```

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