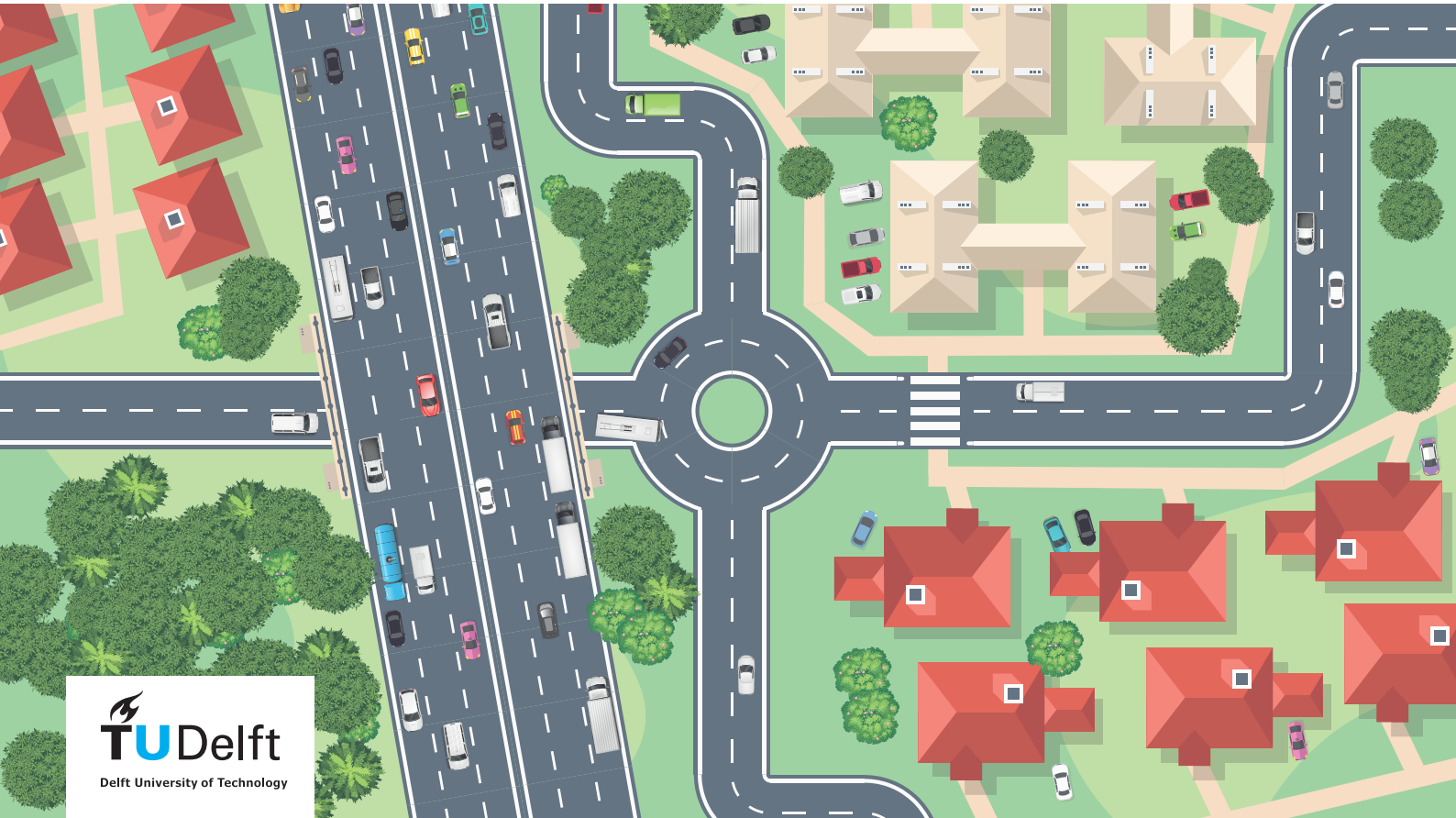
Public support for Tradable Peak Credits as an instrument to reduce congestion

A stated choice experiment that is simultaneously used to investigate the influence of content and medium of stated choice introductions

C. van Langevelde - van Bergen



TU Delft
Delft University of Technology

Complex Systems Engineering and Management

Public support for Tradable Peak Credits as an instrument to reduce congestion

A stated choice experiment that is simultaneously used to investigate the influence of content and medium of stated choice introductions

In partial fulfillment of the degree of Master of Science at the Delft University of Technology, to be defended publicly on August 29, 2019.

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Preface

About a year ago I started searching for the project with which I would complete my master's degree. This caused some concern: will I find a topic that can keep me interested for six months? Well, the answer turns out to be yes. The last six months I have been working on a subject that fascinated me. I increasingly discovered how complex it is and how I, unfortunately, could only work on one small piece of a large puzzle. But I do believe it is an important piece.

I want to thank the members of my graduation committee. Gerdien, thank you for your fresh point of view. It helped a lot to receive feedback from someone less involved in the subject. Furthermore, your expertise was very valuable when I was investigating the influence of the survey introduction. I also really appreciate your positive attitude. Eric, thank you for your thorough feedback. You always took the time to review my work and you actually read everything I send your way. Your expertise on stated choice experiments has greatly helped my research. You even banned Bachelor students from software if this was necessary for my research. I greatly appreciate your commitment. Lizet, thank you for all the time and energy you put in my project. You were very involved and your input was always useful. Because I could meet you every week, I have never been stuck for long. That helped enormously. Thank you for entrusting me to do part of your research.

Thanks to all my friends: for distracting me, for keeping me up my spirits and for reviewing parts of my thesis. Special thanks to Ingeborg, for making my thesis pretty by designing the front page. Shanita and Laurane, I enjoyed the time we worked on our theses together. The many tea breaks, games, delicious lunches and good conversations made the last six months so much more fun. I think I am actually going to miss going to TPM every day to see you guys.

I also want to thank my parents. For the last six months, but mainly for all the time preceding this period. Thanks for giving me the possibility to study. I have always felt supported and you never gave me the idea that I could not do something if I wanted to. Thanks for everything.

Finally, I want to thank Bart. Bart, you always had faith in me and in my abilities, even if I didn't have this at all. Thank you for this and thank you for reminding me of this again and again. It has been so important for me to experience your unceasing support. I also really enjoyed the time together in which I didn't have to think about my studies. Thank you for putting things in perspective if I was too concerned about my studies. You were my rock when I was not very rock-like.

Chris van Langevelde - van Bergen
Delft, August 2019

Summary

This study consists of two parts: the first part investigates the public support for Tradable Peak Credits and the second part investigates the influence of introductions in stated choice experiments on the results of such an experiment.

Public support for Tradable Peak Credit designs

Increasing congestion is threatening accessibility of urban regions and is causing economic damages. Because of the typically low public support for charging instruments, recently interest has increased for a new type of instrument to reduce congestion: Tradable Peak Credits (TPC). The fundamental idea behind this instrument is that a certain amount of credits is allocated to people free of charge and that each ride during peak hours in a certain area costs one credit. The amount of credits that is distributed will be determined based on how much traffic can be allowed in a certain area without causing congestion. People can buy credits from others if they need more, and sell them to others if they do not use them. It is hypothesized that a TPC system has a higher public support in theory compared to conventional congestion pricing. However, this has not been studied. This study therefore aims to answer the following research question:

What is the expected support for the introduction of a TPC system considering different TPC system designs compared to maintaining the current situation, and compared to the introduction of other road pricing policies?

Methodology
A stated choice experiment was conducted among residents of the transport regions Amsterdam and Utrecht. They were introduced with TPC and were presented six choice sets. Each choice set consisted of two TPC systems, which differed with regard to four design variables: who receives credits, how the credits are distributed, how often credits are distributed and how often the price of a credit fluctuates. These design variables were chosen based on a literature review and consultation of road pricing scientists. For every choice set, respondents indicated which TPC design they preferred and whether they would vote for or against the introduction of their preferred TPC system. Also a questionnaire was included to measure socio-demographic variables, mobility habits, attitudes towards TPC and car use, and the support for TPC, congestion charging and kilometer charging. Ultimately, the data of 505 respondents was used. A panel Mixed Logit model was estimated and interpreted to answer the research question.

Findings
Socio-demographic variables and mobility habits did not influence the support for the introduction of TPC. Support is influenced by (1) the general like or dislike of a person for TPC, (2) the design of the TPC system and (3) attitudes towards TPC. (1) Residents of transport regions Amsterdam and Utrecht turned out to be very heterogeneous in liking or disliking TPC in general. (2) Regarding the design of the TPC system, there is a preference for also giving credits to people who work but not live in the municipality and own a car, instead of only giving credits to residents of the municipality. Equal distribution of credits is the preferred distribu-

tion principle, followed by giving more credits to people who drive more kilometers, followed by giving more credits to people who work more hours. The most unsupported distribution principle is giving more credits to people with lower incomes. This indicates that there is a lack of support for TPC as a tool to redistribute welfare. Opinions are however very divided about which distribution principle should be applied. Furthermore, people prefer to receive credits every month over receiving them every week. As expected, people prefer a lower frequency of credit price fluctuations. (3) Various attitudes regarding TPC of people turned out to affect the utility of TPC for them. The variables are discussed in order of how much effect they have on the value of TPC for a person, starting with the variable that has the largest effect. People are more in favor of introducing TPC when: (1) they consider TPC a fair system, (2) they believe that TPC can effectively reduce the impact of car use on the environment, (3) they trust that TPC is feasible and that the government is able to implement and maintain the system, (4) they do not perceive TPC as an infringement on their personal freedom, (5) they expect the trading of credits to be fun.

When you present respondents with three road pricing policies, namely TPC, congestion charge, and kilometer charge, then there is the least support for TPC (26.5%) and the most support for kilometer charge (35%). The support for a congestion charge is quite similar to the support for TPC (28%). The support for a kilometer charge is considerably lower than the support that was found in another recent research in the Netherlands, which was 59% (I&O Research, 2019). TPC thus does not have a higher public support than a congestion charge and a kilometer charge as was hypothesized. So, based on this research, there is currently no reason to favor TPC over a congestion charge or kilometer charge for reducing congestion based on public support.

When presenting people with more specific designs of TPC, where it is specified who receives credits, how credits are distributed, how often credits are distributed and how often the credit price changes, then support for the introduction lies between 33.8% and 53.2%. Considering that TPC is a new and unknown measure compared to the well-known congestion charge and a kilometer charge in the Netherlands, these support levels are quite high. A fairly large group of people, 22.5%, indicated that they are neither for nor against TPC. This group has not yet formed their opinion about TPC and here lies potential for increasing support for TPC. Tthe support level might be increased by familiarizing people with TPC through information and experience. This study also made clear that people are quite critical about TPC. For example, only a limited number of them expect that TPC reduces congestion, and a lot of people think that trading credits will take a lot of time and effort. By giving more information about TPC and familiarizing people with the measure, these types of attitudes might become more positive and this might increase support for TPC. Considering this, and considering the fact that the highest support level for a specific TPC design (53.2%) is almost equal to support levels for other road pricing policies, there is sufficient reason to continue investigating TPC as an alternative to a congestion charge and a kilometer charge.

Recommendations for policymakers

If policymakers want to implement TPC, the main recommendations are the following. (1) Take the public's preferences as discussed under 'findings' into account in order to design a TPC system that can count on sufficient public support. (2) Investigate if a cooperation with employers is possible, so that credits can be provided to them which can in turn be used by their employees that need to commute. (3) Have investigated what credit allocation interval and price fluctuation are necessary for an effective TPC system. (4) When developing the trading platform, pay attention not only to functionality, but especially to how credit trading can be made fun for people. Involve future users in the entire development process. (5) Let people experience credit trading before TPC would actually be introduced, for example with a

mock-up or via a simulation game. In this way, future users can get a better idea of what the system would entail and they can already discover whether they like trading credits.

Recommendations for future research
The main recommendations are the following. (1) Use the ML model with attitudinal variables to evaluate the support of TPC under various scenarios regarding the attitudes towards TPC in the population. (2) Develop a hybrid choice model and use it to predict support for TPC. (3) Investigate whether support for TPC is higher when people have experienced the use of peak credits and credit trading. (4) Perform additional qualitative research to learn more about the reasoning of respondents behind the preferences discovered in this research. (5) Perform the stated choice experiment again with another sample to see whether support levels found are comparable to the ones found in this study.

The effect of medium and information in stated choice introductions

Stated choice experiments are often used to determine preferences of people regarding products, systems or services. Especially when the subject of the experiment is new, it is important to first introduce the subject. Previous studies found that the way in which the attributes are presented influences the outcomes of stated choice experiments. However, to my best knowledge, the influence of the introduction of the subject, the choice options, has not been studied. However, it is observed that researchers make different choices regarding the introduction in their stated choice studies, for example in the type of information they include and the communication medium that is used. Based on literature, it can be expected that these variations in introductions can influence outcomes of the research. Whether and to what extent this is the case is an important knowledge gap. The aim of this study was therefore to answer the following research question:

What are the effects of the medium and content of the introduction in a stated choice experiments on preferences, attitudes and drop out?

Methodology
Four versions were made of the introduction of TPC in the stated choice survey that was used to investigate support for TPC. Between those versions, two aspects of the introduction of TPC and its attributes differed: the type of information that was included and the communication medium that was used. Two types of information were distinguished: (1) only an explanation of how a TPC system works, as neutral as possible, and (2) an explanation of how a TPC system works, and information on the underlying problem that a TPC system should reduce. Also two communication mediums were distinguished: (1) written text, and (2) an animation video with a voice-over and subtitles. Making all possible combinations of these variants, resulted in four versions of the introduction. Each version was presented to a quarter of the respondents. Choice models and independent samples t-tests were used to determine whether there are differences in preferences regarding TPC, in attitudes regarding TPC, and in dropping out of the survey between the groups that received different introductions.

Findings
Variations in communication medium and content in the introduction did not have a significant influence on the choices made by respondents in the stated choice experiment. There was, however, a significant influence on an attitude of respondents that was directly linked to the textual variation in the introduction. This confirms that choices regarding what you discuss in the introduction may influence the results of the study. Specifically, this study made clear

that if you measure an attitude, this measurement can be influenced by discussing information about that attitude in the introduction or not. Furthermore, respondents who received the explanation of TPC via a video found the explanation slightly clearer than respondents who received it in written text. The drop out was not greater when receiving a video instead of text, or the other way around. However, respondents receiving a video mostly dropped out before even starting the video. When they did watch the video, the drop out in the remainder of the survey was lower compared to respondents who received the introduction via written text.

Recommendations for researchers using stated choice experiments

The main recommendations are the following. (1) Be transparent about the introduction that was used in the stated choice experiment, by also publishing this. (2) When choosing your medium, think carefully about your target group. Consider which practical barriers can play a role for your target group and whether they can be overcome. When using a video, there might be barriers such as the costs of data required to watch the video. If such barriers are expected and cannot be removed, it is recommended not to use video, as this can cause a high dropout. If those barriers are not there, or if they can be removed, a video is an interesting alternative to written text. This study showed that if people start watching the video, a video causes less drop out than written text. Also, the introduction via video was perceived as more clear than the same introduction via written text. (3) Keep the introduction to the subject of the stated choice experiment short.

Contents

1 Introduction

1.1 Background of the research

Worldwide, urban regions are rapidly developing and good accessibility is required both socially, for access to certain services, and economically, to limit travel time losses. The increasing congestion is threatening this accessibility and this has several negative effects. For example, congestion caused an economic damage of 1.3 billion euros in 2017 in the Netherlands (NOS, 2018a). It is expected that the congestion will increase in the Netherlands. Compared to 2018, 10% more kilometers will be traveled by 2023, increasing the travel time loss with 35% compared to 2018 (KiM, 2018).

Experts argue that only building new roads cannot solve the problem of growing congestion (RLI, 2018; NOS, 2018b). Other instruments are therefore needed that can reduce congestion. Different types of pricing instruments can be applied, such as rewarding instruments or charging instruments (see Figure 1.1). Rewarding drivers who avoid rush hours is both effective (IenM, 2015; MuConsult B.V., 2013) and popular among participants (Verhoef, 2018). A disadvantage is that only people who use the car can benefit and people who already show the desired behavior (i.e. not take the car) can not. Also, governmental budgets for it are limited (Verhoef, 2018). It can be a suitable solution for tackling the congestion on a particular road on short term. However, scaling up is problematic and it is therefore not a sustainable solution for traffic congestion. Congestion charging and kilometer charging entail that drivers pay on the basis of the use of the car. Although this measure can be very effective in reducing congestion (CPB, 2016), there is a lot of resistance to congestion and kilometer charging in the Netherlands (Verhoef, 2018; Volkskrant, 2016). The current government states that it does not want to introduce it (Nieuwenhuizen Wijbenga et al., 2018; Rijksoverheid, 2017).

A lack of public support is an important barrier for the introduction of an instrument that could effectively reduce congestion. In theory, the government can also introduce such measures if there is limited public support, but it is unlikely that a government will do this. There are two main reasons for this. First of all, choices made by politicians are influenced by the consequences they expect for their popularity and re-election (Frey, 2003; Niskanen et al., 2003). If there is clear public resistance to a measure, introducing this measure is likely to have a negative impact on the politicians responsible for it. Second of all, the introduction of a measure that lacks public support can also cause social unrest, for example in the form of demonstrations (Niskanen

et al., 2003). So, sufficient public support is in practice a prerequisite for introducing a pricing instrument. Literature on road pricing policies supports this by showing that public acceptance is a main barrier for the implementation of road pricing policies (Frey, 2003; Niskanen et al., 2003).

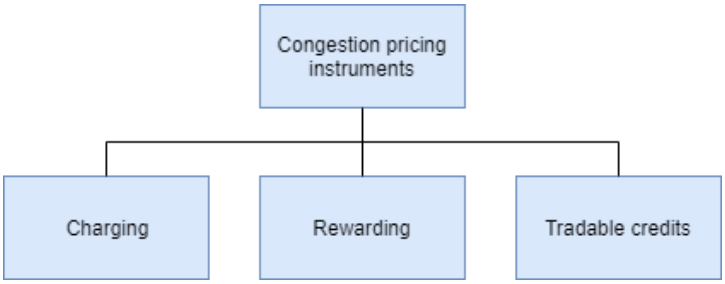


Figure 1.1: Three types of pricing instruments

1.1.1 Tradable credits as an instrument to manage congestion

Because of the typically low public support for charging instruments, recently interest has increased for a new type of instrument: tradable driving credits for mobility management (RLI, 2018; Verhoef et al., 1997-a). There are all several variants of this system discussed in literature with the common feature that they all have some form of tradable driving credits to control the amount of traffic. One of these systems is studied in this research: Tradable Peak Credits (TPC). The fundamental idea behind this instrument is that a certain amount of credits is allocated to people free of charge and that each ride during peak hours in a certain area costs one credit. The amount of credits that is distributed will be determined based on how much traffic can be allowed in a certain area without causing congestion. People can trade the credits, which means that they can buy the credits from others if they need more, and sell them to others if they do not use them (Verhoef, 2018). The precise definition of TPC used in this study is discussed in Section 5.3.1.

Since a cap is set on the number of credits that is issued to drivers, TPC are theoretically effective in reducing congestion. Furthermore, TPC can address equity-issues. Important criticism on conventional charging instruments is that it harms poorer people disproportionally (Verhoef, 2018). TPC address this criticism by allocating a certain amount of credits free of charge. It is also possible to let the number of credits that a person receives depend on certain characteristics such as income. In addition, the system is budget-neutral. This means that there is no revenue flow to the government. As a result, the system might not be perceived as 'another tax', which can have a positive effect on its public support. Due to these characteristics, it is hypothesized that a TPC system has a higher public support in theory compared to conventional congestion pricing. Furthermore, results in research to other types of personal tradable credits strengthen the interest in TPC. Several studies into personal tradable carbon credits showed acceptance levels of about 40% and also showed that there was a preference for tradable carbon credits compared to a carbon tax (Dogterom, 2017). Here we thus observe a preference for tradable credits over a traditional tax. This makes it even more interesting to investigate whether this also applies to the field of congestion management.

1.1.2 Introductions in stated choice experiments

A stated choice experiment will be used to examine whether and how the support for a TPC system depends on the design of the TPC system, as will be explained in Chapter 2. The results

of this experiment can inform transport policy makers in the Netherlands. Results of other stated choice experiments are already used in policy development. It is therefore important that this research method produces valid results. When validating stated choice experiments, attention must be paid on the one hand to the methods for analyzing the obtained choice data and drawing conclusions from this. On the other hand, it is important that the choice data that is collected properly represents the choices that people would make in reality. There is currently little knowledge about how the way in which the topic is explained to respondents in a stated choice experiment influences their preferences regarding that topic. Stated choice experiments often contain non-existing alternatives, which should first be introduced to respondents. A question here is what you include in this introduction. On the one hand it is desirable to be complete, on the other hand people will not have complete information in reality either. In addition, any information you provide may influence respondents. However, it is unknown how large this influence can be. This makes it more uncertain how valid the results of a stated choice experiment are.

1.2 Knowledge gaps

Two literature reviews were conducted in two separate field of literature in order to review the state of the art in these two fields (see Chapter 3). First, it has been reviewed what has already been studied regarding systems with tradable mobility credits. Second, literature on the influence of presenting the choice task in stated choice experiments was reviewed. Both have led to the identification of knowledge gaps.

1.2.1 Knowledge gap 1: public support for the introduction of TPC

So far, research on systems with tradable driving credits for mobility management has mainly been conducted into behavioral effects and effects on the road network of implementing such a system. What is currently lacking is knowledge on how this instrument will be received by the public. As discussed earlier, public support is very important for the introduction of a road pricing measure. It is however unknown how many people would be in favor of introducing a TPC system to reduce congestion. It is also unknown what public's preferences are regarding the choice between a congestion charge, a kilometer charge (two much-discussed alternative of TPC), or a TPC system. Due to certain characteristics of TPC, it is expected that this measure will be preferred to other measures. However, this is not verified. The literature further shows that these preferences with regard to TPC probably depend strongly on the design of the TPC system. There are different design variables and different combinations of these are possible, leading to different TPC systems. Examples of such design choices are which people receive free credits and how the credits are distributed among them. The influence of the design of a TPC system on the public's preferences have not been investigated yet. In order to advice upon the design of a TPC system, it is necessary to understand how preferences of the public depend on the choices in the design variables of this system.

1.2.2 Knowledge gap 2: influence of the introduction in stated choice experiments

Previous studies found that the way in which the attributes are presented in a stated choice experiment influences the outcomes of the experiments, but, to my best knowledge, the influence of the introduction of choice options has not been studied. However, it is observed that

researchers make different choices regarding the introduction in their stated choice studies, for example in the type of information they include and the communication medium that is used. Based on literature, it can be expected that these types of choices can influence results of the experiment. Whether and to what extent these variations in introductions influence these results is an important knowledge gap. Section 1.4 will elaborate on the relevance of studying this influence.

1.3 Research questions

The aim of this research is to fill the identified knowledge gaps. Therefore, the knowledge gaps identified in Section 1.2 are translated into the following research questions (RQs):

1. What is the expected support for the introduction of TPC considering different TPC system designs compared to maintaining the current situation and compared to the introduction of other road pricing policies?

> *1.1 What is the relationship between the design variables of a TPC system and the preference for the introduction of a TPC system?*
> *1.2 What is the relationship between socio-demographic variables, mobility habits, attitudes on TPC and on car use, and the preference for the introduction of a TPC system?*
> *1.3 What are currently the public attitudes towards a TPC system?*
> *1.4 To what extent is the introduction of a TPC system preferred to maintaining the current situation?*
> *1.5 To what extent is the introduction of a TPC system preferred to the introduction of other road pricing policies, specifically a congestion charge and a kilometer charge?*

2. What are the effects of the medium and content of the introduction in a stated choice experiments on preferences, attitudes and drop out?

> *2.1 What are the effects of the type of information included on preferences and attitudes?*
> *2.2 What are the effects of different communication mediums, specifically plain text and an animation video with a voice-over on preferences, attitudes and drop out?*

1.4 Scientific and societal relevance of the research

1.4.1 Research question 1: public support for the introduction of TPC

Scientific relevance
There is still little empirical research into public opinion towards measures with tradable rights in mobility. Little is therefore known about what the public thinks of these types of systems and about their support for these systems. This research enriches the literature by providing empirical data that reflects the preferences of the public. This concerns both preferences with regard to the design of the TPC system, and preferences with regard to the choice between TPC and the current situation, and the choice between TPC, a congestion charge and a kilometer charge. This way a number of scientific knowledge gaps are filled.

Societal relevance
Due to certain characteristics of TPC, it is expected that this measure will be preferred to other measures. However, this is not verified. For policy makers, it is very relevant to know this. Sufficient public support is in practice a prerequisite for introducing a system like TPC as

discussed in Section 1.1. This study provides insight into whether there is more public support for the introduction of TPC compared to the introduction of a congestion charge, a kilometer charge or maintaining the current situation. Introducing a TPC system is probably more complicated than introducing a congestion or kilometer charge. It might therefore be the case that introducing a TPC system is only considered when acceptability levels are considerably higher than acceptability levels of congestion or kilometer charging. So, this study helps policy makers to determine whether the support for TPC is high enough to consider it as a policy to reduce congestion in the Netherlands. Furthermore, insight in how the specific design of the TPC system influences the preferences is valuable. If it would be decided to introduce a TPC system, the characteristics of the system must still be designed. This research informs this design activity by providing insight into how certain characteristics of the system must be designed to achieve public support. Finally, insight is also gained into how different characteristics of people are related to support for TPC. This makes clear which groups of people are more or less in favor of TPC. In sum, this research provides useful insights for policy makers and researchers for further developments of price instruments in traffic.

1.4.2 Research question 2: influence of the introduction in stated choice experiments

Scientific relevance
It is known that many aspects of a message can influence the opinion that people form after the message. Based on this, we expect that this can also influence preferences. There is however little research into the influence of the introduction of the choice options in stated choice studies on the choices made by respondents. It is very relevant to know whether there is an influence and especially how great this influence is. If choices of respondents would depend heavily on the introduction of the choice options, this would raise doubts on the validity and usefulness of the results. This exploratory research is a first effort to gain more knowledge about this. In this way, more insight is gained in how to apply stated choice in scientific research. Finally, insight from this research might also change the view on what information should be included in stated choice introductions. It now appears to be the standard to introduce the choice options as neutral as possible, considering the studies that have published their introductions and considering Ben-Akiva et al. (2018). However, with a measure such as TPC, there is little chance that people in reality become familiar with TPC in such a neutral way. Road pricing measures are often discussed in the media. In news articles the social context and the (expected) implications of such a measure are also discussed. Explaining both the measure and the social context, therefore seems a more realistic representation of how people will come into contact with the measure in reality. Then the results of a stated choice experiment that also include this information in the introduction might be more valid.

Societal relevance
Gaining insight in the influence of the introduction of choice options contributes to assessing the validity of stated choice experiment results. This research can be a first step in further research into what the introduction should be like to get the most valid results. Stated choice is a commonly used method and results are for example used in policy development. Therefore, gaining this knowledge can in turn ensure that more valid results from stated choice studies are used for policymaking in the future.

1.5 Position of this research and accountability for collaboration

This research is part a larger study on stakeholder acceptability of smart pricing measures, which is the PhD project of Lizet Krabbenborg. This PhD project is part of the U-SMILE project that is led by Prof. dr. Erik Verhoef. Lizet had the idea to study tradable credit systems with a stated choice experiment and to study the influence of the way TPC is explained in such an experiment. I have further shaped this assignment in consultation with her. Mainly the data collection in the form of the stated choice experiment will be used in her research. We therefore collaborated in setting up and conducting the stated choice experiment. It will now be explained how this collaboration went and what tasks Lizet performed in this study.

- Consultation of road pricing scientists
  Lizet and I were both present in the discussions with road pricing scientists. I had prepared the discussions and took the lead during the discussions. Lizet took part in the conversation and asked additional questions.

- Introduction text TPC
  The text that explained TPC to respondents in the survey was prepared in collaboration with Lizet. Lizet wrote a first version, and I then iteratively improved it based on my own insights and input from road pricing scientists.

- Videos
  The videos that explained TPC to respondents in the survey were entirely made by Lizet.

- Statements for measuring attitudes in questionnaire
  The statements for measuring attitudes that were used in the questionnaire were iteratively found and constructed in collaboration with Lizet.

- Contact with the company that recruited respondents
  All agreements with the company that recruited respondents were made by Lizet. She maintained contact with the company before the survey was distributed to respondents. During the time that respondents were able to complete the survey, I maintained contact with the company about the progress and any problems.

The other tasks were performed independently by me and not in collaboration with Lizet. The most important of these are:

- Two literature studies to substantiate two scientific knowledge gaps (Chapter 3);
- One literature study to provide an overview of design variables of a TPC system (Chapter 4);
- The design of the stated choice experiment (Section 5.4);
- Execution and analysis of the pilot survey (Section 5.8);
- Programming the online survey;
- Data analysis and interpretation (Chapters 6 - 10).

During these tasks I received feedback and advice from the entire committee.

1.6 Report outline

Chapter 2 discusses the research methods that were used to collect and analyze the data in order to answer the research questions. It is explained why the methods were chosen and how the methods were used.

Chapter 3 embeds this research in existing literature. It discusses the two literature reviews that have been conducted that led to the discovery of scientific knowledge gaps. For each of these two knowledge gaps, a research question was formulated. Section 3.1 presents the literature review on systems with tradable driving credits for mobility management and discusses what is already studied and which relevant knowledge gaps still exist. This led to the formulation of knowledge gap 1 and RQ 1. Section 3.2 presents the literature review on the influence of the introduction in stated choice studies that led to knowledge gap 2 and RQ 2.

Chapter 4 provides an overview of the design variables of a TPC system. This overview is based on a literature study, focus groups held by Krabbenborg (Krabbenborg et al., 2019) and consultation of experts. These design variables were needed to serve as attributes in the stated choice experiment.

Chapter 5 discusses how the survey and the stated choice experiment were designed. It is also discussed how the final survey was constructed and distributed.

Chapter 6 and 7 present the analysis of the data gathered through the stated choice experiment and the survey. Chapter 6 discusses the results that link to RQ 1 and Chapter 7 discusses the results that link to RQ 2.

In Chapter 8, the choice model obtained in Chapter 6 is applied to predict the level of support for various TPC designs. Insights obtained from this can be used to provide policy makers with recommendations on the design of a TPC system.

Chapter 9 draws conclusions by answering the research questions posed at the start of the study.

Chapter 10 ends the thesis by reflecting on the possible limitations of the research and by providing recommendations regarding policy and future research.

2 Methodology

This chapter discusses the research methods that will be used to collect and analyze the data in order to answer the research questions. Figure 2.1 provides an overview of the entire study. The subsequent sections then elaborate on the individual research methods. Section 2.1, 2.2 and 2.3 are linked to RQ 1, and Section 2.4 to RQ 2.

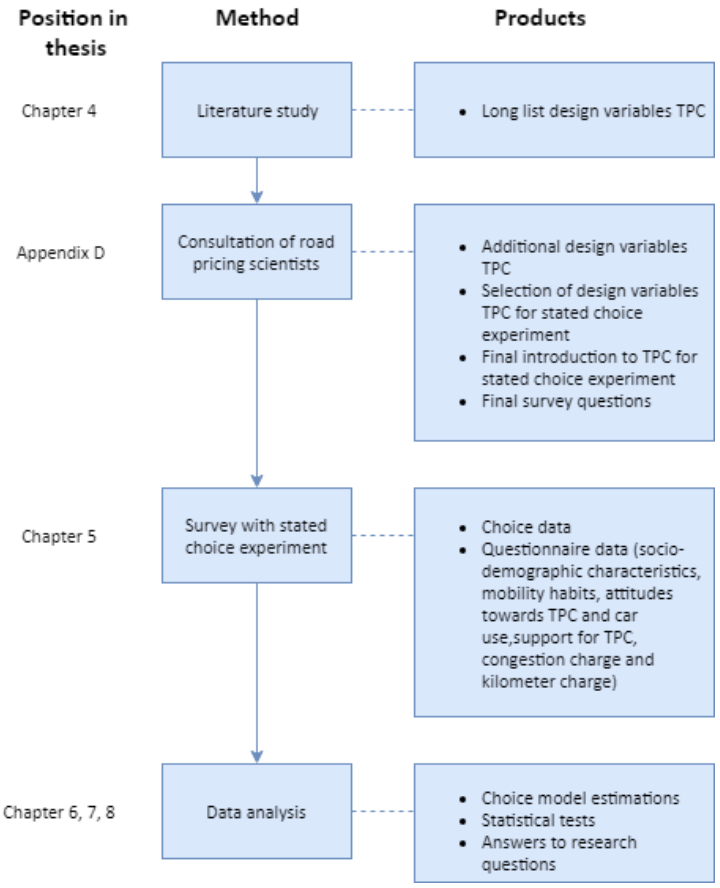


Figure 2.1: Overview of the research methods, the products that result from these methods and the place where it is documented in this thesis

2.1 Literature study

To answer RQ 1.1 it is necessary to know what the design variables of a TPC system are. First, a literature study will be conducted to identify such design variables. The literature study focuses on literature on existing or proposed systems with tradable driving credits for mobility management. Since literature on tradable driving credits is limited, also literature on other systems with personal tradable credits will be used, for example literature on persona; emission credit systems. In literature on tradable mobility credits, it will be investigated which design variables are already identified. Subsequently, for comparable systems, it will be checked which design variables have been identified, and it will be assessed whether these design variables also apply to TPC systems. This results in an overview of design variables of a TPC system. This overview will be supplemented with insights from focus groups held by Krabbenborg (Krabbenborg et al., 2019). In these focus groups, potential participants in a TPC system discussed such a system. This provided a user perspective on TPC systems and proved to be a valuable addition, as design variables emerged that were not identified in the literature study. The literature study and the overview of design variables is presented in Chapter 4. Databases Scopus and Google Scholar were used to select literature. The search strategies that will be used are presented in Appendix A.

2.2 Consultation of road pricing scientists

Four scientists who study road pricing policies will be consulted. They will be asked to validate and supplement the list of design variables that will be drawn up on the basis of the literature study and focus groups. Since only a limited number of attributes can be included in a stated choice experiment (see Section 2.3), the road pricing scientists will also be consulted on which design variables to include as attributes. A criterion to make this selection of design variables is the degree of influence that the design variable is expected to have on the public's preferences regarding the introduction of the TPC system. The scientists will thus be asked which design variables they expect to influence the preferences of the public the most. During the literature study it will also be reviewed whether the level of influence of design variables on the public's preferences was discussed. But as it is expected that little will be found here since the literature on mobility in this area is scarce, it is decided to use the consultation of scientists in addition. Finally, they will be asked to provide feedback on how TPC and its design variables are explained to respondents in the stated choice survey. This will iteratively improve this introduction.

Scientists from different fields will be selected to get a varied and as complete as possible perspective on TPC systems. The most important insights from these discussions are included in Appendix D.

2.3 Stated choice experiment

RQ 1 focuses on uncovering the public's preferences with regard to TPC. First of all, we want to know whether there is a preference for the introduction of a TPC system compared to maintaining the current situation. In addition, we also want to discover the influence of different variables on these preferences. Preferences can be derived from observing and analyzing choice behavior. This is what is done in discrete choice analysis. This method can be used to analyse and predict choices that a person makes from a set of alternatives (Koppelman & Bhat, 2006). This allows to determine the relative influence of different attributes of the alternatives on

the decision (Koppelman & Bhat, 2006). First, it is explained how the data that is required to answer RQ 1 will be collected with a stated choice experiment (Section 2.3.1). Next, it is discussed how this data will be analyzed with discrete choice models (Section 2.3.2). A more elaborate explanation of the underlying theory is provided in Appendix H. An explanation for people who are not yet familiar with stated choice experiments is provided in the text box below. The design of the stated choice experiment is discussed in detail in Chapter 5.

Simple explanation of stated choice experiments
Respondents are presented with a choice between two TPC systems. These TPC systems differ from each other in a number of characteristics, for example in who receives credits. For example, in TPC system 1 all residents of the municipality receive credits, while in TPC system 2 only residents who own a car receive credits. The respondent chooses the TPC system of his/her preference. The respondent is presented with several of such choices. This yields a lot of observations of choices that respondents have made between TPC systems. These observations are used by the researcher. With mathematical models you can deduce to what extent the different characteristics of the TPC system influence the choice of the respondent. For example, you can find out that preferences that people have about who receive credits have a greater influence on their choice between two TPC systems than their preferences about how often credits are distributed. So you actually determine how important different characteristics are for a respondent who has to choose between two TPC systems. The researcher can then also use these insights to predict for new choice sets which TPC system people would choose. In this study, respondents are also asked to choose between introducing a TPC system and not introducing a TPC system. This makes it possible to predict for a TPC system with certain characteristics how many people would be in favor of introducing it and how many people would be against introducing it.

A so-called MNL model can be used to reveal the importance of TPC characteristics for the choice of respondents and to predict choices. However, a MNL model makes a few incorrect assumptions which has drawbacks. An example is that a MNL model assumes incorrectly that preferences regarding characteristics of TPC do not vary among respondents. A ML model can be used instead of a MNL model to avoid those drawbacks.

2.3.1 Data collection: stated choice

In discrete choice analysis, a decision needs to be made between using Stated Preference (SP) data and Revealed Preference (RP) data. SP data concerns choices that people make from a set of hypothetical alternatives that are presented to them in a survey setting (Train, 2009, p. 156). RP data concerns choices that people make in real-world situations (Train, 2009, p. 156). It is impossible to use RP data in this research for two reasons: TPC is a new system that does not yet exist in the real world and even if it would exist, people would not have the option of choosing to adhering to it or not or the option of choosing between multiple TPC systems. Therefore, SP data was used in this research.

The SP data will be collected via a stated choice experiment in the form of a digital survey among people of 18 years and older who live in the transport region Amsterdam or Utrecht (Section 5.6 will elaborate on this choice). At the start of the survey, respondents are first introduced with the concept of a TPC system as they are most likely not familiar with this system. After this introduction, multiple choice sets are presented to the respondents. The choice sets each consist of two different TPC systems. The TPC systems inside one choice set differed with regard to their attributes (their design variables). Which attributes will be

included will be decided based upon the literature study (Section 2.1), the consultation of experts (Section 2.2) and own considerations. Respondents are asked to indicate for every choice set which TPC system they prefer. After this the respondents are asked to choose between the introduction of their preferred TPC system and maintaining the current situation. By giving respondents this choice, it was possible to analyse the extent to which the introduction of a TPC system is prefered to maintaining the current situation. In addition to the stated choice experiment, the survey also included a questionnaire with questions and statements. These were needed to determine the influence of socio-demographic variables, mobility habits, attitudes on TPC and attitudes on car use on the preference for the introduction of a TPC and thus answer RQ 1.2. Furthermore, statements have been added on congestion charge and kilometer charge to determine the extent to which introduction of TPC is prefered to these alternative road pricing policies and thus answer RQ 1.5. This will be discussed in more detail in Section 5.5.

2.3.2 Data analysis: discrete choice models

Discrete choice models
Discrete choice models can be used to analyse choice behavior. They can uncover to what extent different variables influence the choice of a person (Koppelman & Bhat, 2006). They furthermore allow to predict future choices of people (Koppelman & Bhat, 2006). This is exactly what is needed to answer RQ 1.1, 1.2 and 1.4.

The utility function
The most commonly used discrete choice models, which will also used in this study, are based on the random utility maximization (RUM) theory. These models assume utility maximization as the decision rule (Train, 2009). This means that an individual will choose the alternative that maximizes his or her utility (Koppelman & Bhat, 2006). Utility is 'an indicator of value to an individual' (Koppelman & Bhat, 2006, p.14). In the stated choice experiment, there will be three alternatives from which respondents choose: TPC system 1, TPC system 2 or no TPC system. Every alternative has its own utility function, that determines the utility of that alternative. The total utility of an alternative for an individual consists of two parts: the systematic utility and the error term. The utility that can be related to the observed factors is the systematic utility. The observed factors are both the attributes of the TPC systems that are presented in the choice task (e.g. the recipients of credits) and the variables that were measured in the survey (e.g. the age of the respondent) (Koppelman & Bhat, 2006). The utility that can be related to the unobserved factors is captured in the error term. For every observed factor that is part of the utility function, a parameter (β) will be estimated. The parameter denotes the weight of the factor. By multiplying this parameter with the value of the factor, the value that results is the contribution of that factor to the utility. Based on the observed choices in the stated choice experiment, the parameters for the attributes (β's) are estimated using the maximum likelihood principle (Koppelman & Bhat, 2006). This means that the set of parameters is found which makes the choice data most likely. In addition, a utility function can also contain an alternative specific constant (ASC). The ASC is the utility of the alternative when the values of all attributes are zero. Therefore, the ASC captures the preference for an alternative that cannot be explained by the observed factors (Koppelman & Bhat, 2006). It thus represents the utility that people derive from their associations with the 'label' of the alternative (for example the label 'TPC' or 'hyperloop') that are not included as attributes in the experiment. In this study, the utility function of the TPC alternatives contain an ASC that captures the general preference for TPC compared to maintaining the current situation. Also interaction effects can be included in the utility function. This means that the

utility contribution of a factor is dependent on the value of another factor. For example, the utility contribution of a certain way of distributing credits among recipients is dependent on the age of a respondent.

Choice probabilities
The utility of alternatives is used to calculate choice probabilities: the chance that an individual will choose a certain alternative from a set. In this study, we are interested in the chance that an individual prefers the introduction of a TPC system over maintaining the current situation. In order to calculate these choice probabilities it is however necessary to make an assumption on the probability distribution of ε (Koppelman & Bhat, 2006). Different choice models make different assumptions. The different models will be discussed in the next section.

The estimated choice models

- Multinomial Logit model
  First of all, a multinomial logit (MNL) model will be estimated. This is the most widely used model and popular due to its simplicity. The MNL model assumes that the error terms associated with the alternatives all have the same probability distribution and that they are all mutually independent (the i.i.d. assumption) (Louviere et al., 2000). The main drawbacks of the MNL are related to this assumption. The mixed logit model that is discussed next deals will explain what the drawbacks of MNL are and how it deals with those drawbacks.

- Mixed logit model
  A ML model will also be estimated to deal with some of the limitations of the MNL model. First of all, nesting effects will be captured with the ML model. It is expected that the error terms of the TPC alternatives are correlated due to the similarity of these alternatives. The i.i.d. assumption does not hold then and can lead to biased parameter estimates. An additional error component will be added to the utility functions of the TPC alternatives that represents the utility of their common unobserved factors. Secondly, panel effects will be captured. The MNL model wrongly assumes that choices made by the same individual are uncorrelated. It is realistic that they are correlated, since individuals have tastes and preferences that influence their choices. By assuming that the choices are uncorrelated, the model will underestimate the standard errors of parameters. ML models can solve this problem by capturing panel effects, which means that the choices that are made over time by an individual are correlated. Thirdly, it will be tested whether there is taste heterogeneity among the respondents by letting β's vary. In the MNL model, it is wrongly assumed that tastes for attributes do not vary across individuals, by having fixed β's.

Model fit
Both a MNL and a ML model will be estimated, but only the model with the best model fit will be used to answer the RQs. Different measures can be used to assess how well the model fits the observed choices. The log-likelihood is such a measure. Log-likelihoods of the MNL and ML model can be compared to determine which model to use. However, since a model is based on a sample it is possible that a higher log-likelihood is based on coincidence. The likelihood ratio test or the Ben-Akiva & Swait test can be used to assess whether the differences in log-likelihoods are significant (Koppelman & Bhat, 2006). The rho-square value (ρ^2) is also a widely-used measure for the goodness of fit of a model (Koppelman & Bhat, 2006). The value of ρ^2 lies between 0 and 1 and can be interpreted as the percentage of initial uncertainty that is explained away by the model. A value of 1 implies a perfect model fit, meaning that every choice is predicted correctly. There is however no guideline for what a good value of ρ^2 is. The rho-squared value will always increase when variables are added to the model, independent of

how significant these variables are. The adjusted ρ^2 penalizes the addition of variables that do not improve the model (Koppelman & Bhat, 2006).

2.4 Varying introductions stated choice experiment

In order to study the effects of different aspects of the stated choice introduction and answer RQ 2, four versions of the survey will be made. Between those versions, two aspects of the introduction of TPC and its attributes will differ: the type of information that is included and the communication medium that is used. Two types of information are distinguished:

- Only an explanation of how a TPC system works, as neutral as possible;
- An explanation of how a TPC system works, and information on the underlying problem that a TPC system should reduce.

Also two communication mediums are distinguished:

- Written text;
- Animation video with a voice-over and subtitles.

Making all possible combinations of these variants, results in four versions of the introduction (see Figure 2.2). Each of the four versions of the survey will be presented to a quarter of the respondents. Data analysis will be used to determine whether there are differences in preferences regarding TPC, attitudes regarding TPC, and dropping out of the survey between the groups that received different introductions. More specifically, the choice models (see Section 2.3.2) and independent sample t-tests are used.

Introduction version 1 -Explanation TPC -Video	**Introduction version 2** -Explanation TPC -Text
Introduction version 3 -Explanation TPC & problem -Video	**Introduction version 4** -Explanation TPC & problem -Text

Figure 2.2: Introduction versions

3 Literature review

Two literature studies have been conducted in two different scientific fields. The first literature study provides background information on tradable credits, and specifically tradable driving credits for mobility management (Section 3.1). Based on this, knowledge gaps were identified that led to RQ 1. The second literature study focused on the influence of the way of presenting a choice task in a stated choice experiment on the results of that experiment (Section 3.2). Based on this, knowledge gaps were identified that led to RQ 2. Appendix A shows the search strategies used in the literature studies.

3.1 Literature on tradable driving credits for mobility management - RQ 1

The literature review aimed to answer the following questions. The number behind the question indicates the section in which the question is discussed.

- What is the background of tradable peak credits? (Section 3.1.1)
- What are current applications of tradable credit systems? (Section 3.1.1)
- In which research domains other than mobility are tradable credit systems studied and what insights does this provide? (Section 3.1.2)
- What has already been studied in the field of tradable peak credits and other systems with tradable driving credits for mobility management? (Section 3.1.3)
- What important knowledge gaps still exist regarding a tradable peak credit system? (Section 3.1.5)

These knowledge gaps have been translated into RQ 1.

3.1.1 Tradable credits

Tradable credits is a category which covers different instruments (Raux, 2004). The overarching characteristic of these instruments is that entities who use a certain scarce resource are constrained in this, by granting them rights to consume a certain amount of the resource (Raux, 2004). These rights can be traded with other entities. This instrument is theoretically founded

on Coase's (1960) theory that states that externalities arise due to a lack of property rights. He illustrates this idea with an example of a factory that produces unlimited smoke that is harmful to others (an externality). Tradable credits can introduce property rights and thus counteract externalities, such as congestion and emissions.

There are various applications of tradable credits, which apply to various types of resources. Applications exist for air pollution control, water pollution control, land use control, catch control in fisheries and managing water resources (Tietenberg, 2002). A well-known application is the European Union Emission Trading Scheme (EU ETS), where, among others, factories need credits for greenhouse gas emissions and can trade these credits among each other.

Tradable credits can be applied at different levels. The EU ETS is an example of a system were credits on a company-level are used (Dutch Emissions Authority, n.d.). Credits can also work on the level of individuals. The research that is proposed in this paper will only focus on credits on an individual level. This thesis will refer to credits on the level of individuals as 'personal' credits.

3.1.2 Personal tradable credits

Several studies have been conducted into personal tradable credits. Much attention is paid in literature to personal carbon trading (PCT) to reduce emissions (e.g. Raux, Croissant, & Pons, 2015; Fawcett, 2010; Bristow et al., 2010). This idea is developed in the mid-1990's and since then several studies on the subject have been carried out (Fawcett, 2010). PCT is an umbrella term for various policy proposals. The common features are the following: a cap is set on the amount of emissions, emission credits are distributed (often for free) among recipients, credits are required for all emissions from household energy and/or personal travels, recipients can trade credits and the cap is reduced over the years in order to reduce emissions (Raux et al., 2015; Fawcett, 2010).

PCT is not yet applied in practice. Serious interest was shown in the measure by the UK government, but in 2008 they called it a policy "ahead of its time" (Defra, 2008). Their biggest objections were the high costs and the expected limited public acceptance.

Various aspects of PCT have been investigated. Fawcett (2010) conducted a literature review into the studies on PCT. This shows that the implementation of PCT seems technically feasible, although there are still aspects that need to be further elaborated upon. Fawcett (2010) furthermore shows that PCT is at least as acceptable as, and is often preferred to, a carbon tax by the public. This is an interesting outcome, since the UK government cites an expected lack of public acceptance as a reason for not (yet) introducing PCT. The main reasons for preferring PCT are its fairness and effectiveness. The main reasons for not preferring it are concerns about implementation and unfairness (Fawcett, 2010). Interesting is that fairness is both mentioned as an argument for and against PCT. Since everyone would receive the same share of credits, PCT can be considered fair. Everyone then has 'an equal right to emit carbon' (Fawcett, 2010, p. 6870). However, 'due to people's differing circumstances, an equal share may not be as fair as it first seems' (Defra, 2008, p. 11). For example, the state of a person's house or a person's income can cause someone to need more carbon credits than someone else. Then the question is whether an equal distribution of credits is actually fair.

3.1.3 Tradable driving credits for mobility management

In transportation literature, systems with tradable driving credits are now increasingly suggested as instrument to restrict congestion and/or emissions. There are several variants of

this system discussed in literature with the common feature that they all have some form of tradable driving credits to control the amount of traffic. The basic idea of these systems is that entities are allocated credits to drive their car and that they can trade these rights with each other when they need more or less (Dogterom, 2017; Fan & Jiang, 2013). By introducing a form of property rights in this way, overconsumption can be prevented (Bao et al., 2013).

Tradable driving credit systems theoretically have various advantages over alternative measures, such as conventional road pricing. Researchers seem to agree on the benefits of a tradable driving credit system compared to other methods of restricting emissions and congestion. First of all, tradable driving credit systems are revenue-neutral, in the sense that there are no cash flows between the participants and the government (Stevens & Verhoef, 2013; Yang & Wang, 2011). Hence, this may improve public support. Secondly, since the government can determine the amount of credits that is allocated to participants, it can make sure that congestion or emissions are reduced to the desired extent (Yang & Wang, 2011; OECD, 2001). Furthermore, by making the initially allocated credits free, the public acceptance is raised (Yang & Wang, 2011; OECD, 2001). Also, participants can receive benefits by selling their rights (OECD, 2001). Fawcett (2010) discusses two characteristics of personal carbon trading that may contribute to behavior change: frequent feedback on behavior via an account that holds driving credits and 'the psychological effect of having an allowance, which will decrease by a known amount over time, and trying to live within that'. Equivalents of these characteristics also apply to tradable driving credits. If these characteristics do indeed contribute to the desired behavioral change, they can also be seen as advantages of tradable driving credits.

In this study, one specific system that falls under this category of systems with tradable driving credits is examined: Tradable Peak Credits (TPC). What exactly is considered a TPC system in this study is discussed in more detail in Section 4.2. An important characteristic of TPC is that a credits concerns the right to drive in peak hours on certain roads. It can be a solution for the congestion problem (RLI, 2018), as congestion can be reduced by issuing only a limited number of these credits (Stevens & Verhoef, 2013).

Several studies have already been carried out into tradable driving credits. The remainder of this section provides an overview of what has already been studied with the purpose of identifying knowledge gaps. Table B.1 in Appendix B provides a non-exhaustive overview of scientific papers that investigated tradable driving credit systems. This table also shows what aspects are investigated in the various papers. This overview shows that many papers propose a specific tradable driving credits system, and then investigate certain aspects related to that proposed system. There is also literature that does not address one specific system. Fan & Jiang (2013) have for example constructed an overview of proposed tradable mobility credits schemes in literature, pointed out similarities and differences between them and discussed advantages and disadvantages of certain schemes.

Behavioral effects and effectiveness

As can be seen in Table B.1, an aspect that is currently mainly researched in literature, is whether tradable driving credit systems can be effective in reducing congestion and/or emissions (Goddard 1997; Raux, 2004; Kockelman & Kalmanje, 2005; Yang & Wang 2011; Xiao et al., 2013; Gao & Sun, 2014; Xu & Grant-Muller, 2016; Dogterom, 2017; Dogterom et al., 2018). Yang & Wang (2011) use mathematical programming to show that credits can lead to desirable network flow patterns. A precondition is that the initial distribution of credits and the rates (amount of credits that you have to pay at a certain place at a specific time) are appropriate. Xiao et al. (2013) propose a tradable credit system to manage traffic congestion during the morning rush period. Drivers need credits to drive past a bottleneck, and the amount of credits needed is time-dependent. The conclusion of the study is that this system can effectively reduce congestion when the right credit charging scheme is in place. Xu & Grant-Muller (2016) propose

a system where credits represent vehicle-kilometers travelled (VKT) and the initial allocation of credits is free. The amount of credits that is distributed is based on the target of desired VKT reduction in the area. Based on a simulation analysis and case-study it is concluded that the system can reach the reduction target. However, since the system does not include time and space factors, it is expected to be ineffective in tackling local congestion. Stated adaptation research carried out by Dogterom (2017) provides empirical insight in the expected reduction of kilometers travelled under a tradable driving credits system where a credit represents one kilometer and credits are needed for all driven kilometers. The number of kilometers driven could be reduced by around 20-24 percent. However, the credits were not only needed during rush hour, so it is unclear whether the kilometers during rush hour would also be reduced with this amount. This makes the effect of the system on congestion uncertain.

These various studies investigated different forms of tradable driving credit systems; these systems all work slightly different. Based on these studies, it appears that tradable driving credit systems can have the desired effect on traffic flows in theory. Preconditions for this are that the initial distribution and the credit rates are appropriate, and that the times and places of driving are taken into account in the system. It should be noted that the effects of tradable driving credit systems on traffic flows are not tested in practice.

Technical feasibility
Technologies to realize systems with tradable driving credits already exist, such as smart cards and radio transmitters that are installed in cars (Grant-Muller & Xu, 2014). However, such systems can entail high costs compared to other road pricing policies such as, for example, a simple tax.

Design
As stated before, various systems with tradable driving credits are suggested. The specific design of the system differs per system. The current literature therefore provides insight in the different tradable driving credit system designs that are possible (e.g. Fan & Jiang, 2013; Raux, 2004; Verhoef et al., 1997-a). Chapter 4 deals extensively with the various design variables that exist.

Public opinions and support
Table B.1 shows that mainly economic and mathematical research has been done into tradable driving credit systems. Most research is now limited to theories and models. Little empirical research has yet been done that actually involves the public or future users of the system. This also means that the public support for tradable driving credit systems has been examined to a limited extent. Only two studies could be found in which future users were asked to express their opinion about the system. Dogterom (2017) investigated the acceptability of a kilometer-based Tradeable Driving Credits system among car users, and the influence of several factors on this acceptability. Acceptability was measures in the following way. Dutch respondents were asked: How acceptable is Tradable Driving Credits overall to you? Chinese respondents were asked: In general, do you think Tradable Driving Credits is acceptable to you? Respondents could answer on a scale of 1 to 7, where 1 meant 'highly unacceptable' and 7 'highly acceptable. Acceptability was defined as the percentage of people that answered a 5, 6 or 7 to this question. Dogterom found an acceptability level of 67% in Beijing and an acceptability level of 22% in the Netherlands. Furthermore, Kockelman & Kalmanje (2005) investigated how several aspects influenced the support of a credit-based congestion pricing system by the public. In this system, drivers received a monthly allowance of credits that could be spend on using the road. Credits were however not tradable. Kockelman & Kalmanje (2005) found that 25% of the respondents supported this policy in the USA. It is unclear how they defined and operationalized support in their research. Support for systems with tradable driving credits thus seems low in western countries.

3.1.4 Variables that may influence acceptability of TPC

Several variables are identified that influence the acceptability of road pricing measures (Dogterom, 2017; Sun et al., 2016, Hamilton et al., 2014; Dieplinger & Fürst, 2014; Bolderwijk et al., 2013; Eriksson et al., 2006; Jaensirisak et al., 2005; Fujii et al., 2004; Schade & Schlag, 2003; Harrington et al., 2001; Jacobsson et al., 2000; Rienstra et al., 1999; Verhoef et al., 1997-b). Dogterom has examined the effects of such variables on the acceptability of the tradable driving credit system he studied. However, as discussed before, this tradable driving credit system is not completely the same as a TPC system. Therefore it is not certain whether these variables also influence the acceptability of TPC. Based on the aforementioned sources, the following variables may influence the acceptability of TPC: 1) attitudes towards the system, specifically perceived fairness, perceived effectiveness, perceived infringement on freedom, perceived infringement on privacy and expected personal outcome, 2) more general attitudes, specifically problem perception concerning both congestion and pollution, trust in public agencies (in their ability to design and manage such a system) and behavioral control 3) socio-demographic characteristics and, 4) mobility habits of individuals (such as the number of times a person travels in peak hours during a week).

3.1.5 Knowledge gaps

Researchers seem to agree that tradable driving credit systems would theoretically be good instruments to reduce congestion. However, there is limited research into the public support for such systems. There are two studies into the acceptability of tradable driving credit systems, but both systems were fundamentally different from the TPC system that is central to this study. Dogterom (2017) examined the acceptability of a tradable driving credit system, but this system did not specifically have peak credits. It cannot be assumed that the acceptability of this will also apply to a TPC system. Kockelman & Kalmanje (2005) did examine the support of a system with credits of which the price is time and place dependent. However, in this system credits were not tradable. Also, this research took place in the USA, leaving it unclear whether their findings would also apply to the Netherlands. Therefore, research on the public support for a TPC system is lacking. It is unknown how many people would be in favor of introducing a TPC system to reduce congestion. It is also unknown what the public's preferences are regarding the choice between a congestion charge, a kilometer charge (two much-discussed alternatives of TPC) or a TPC system. Due to certain characteristics of TPC, it is expected that this measure will be preferred to other measures. However, this is not verified. For policy makers, it is very relevant to know this, as congestion charging is an alternative measure to reduce congestion. Introducing a TPC system is probably more complicated than introducing a congestion or kilometer charge. It might therefore be the case that introducing a TPC system is only considered when acceptability levels are considerably higher than acceptability levels of congestion or kilometer charging.

Furthermore, the extent to which design variables of a TPC system influence the public's preferences regarding the introduction of a TPC system is unknown. In existing studies, the acceptability of one system design is tested. However, there are different design choices possible in such a system, and different combinations of them lead to different systems. Examples of such design choices are which people receive free credits and how the credits are distributed among them. It is plausible that these choices affect the public's preferences regarding the system. This expectation is supported by research to the public acceptability of a personal carbon trading scheme, where Bristow et al. (2010) discovered that this acceptability strongly depends on the design of this scheme. Dogterom (2017) also acknowledges that many design choices have to be made about a system with tradable driving credits and that these probably

influence acceptability. Only testing public acceptability of a fixed tradable credits design is therefore a shortcoming in current studies.

Next to system design variables of a TPC system, it is expected that attitudes towards TPC, more general attitudes such as problem perception, trust in public agencies and behavioral control, sociodemographic characteristics and car-use related characteristics also influence the preferences regarding the introduction of TPC. This is however not investigated yet.

In sum, three knowledge gaps were identified:

- The public's preferences for the introduction of a TPC system over the current situation, over the introduction of a congestion charge and over the introduction of a kilometer charge;
- The influence of system design variables on the public's preference regarding the introduction of a TPC system in the Netherlands;
- The influence of attitudes towards TPC, problem perception, trust in public agencies, behavioral control, sociodemographic variables and mobility habits on the public's preference regarding the introduction of a TPC system in the Netherlands.

3.2 Literature on the influence of the introduction in stated choice experiments - RQ 2

It is expected that the way in which the choice task is presented in a stated choice experiment can influence the results of the experiment. This includes the introduction to the choice task, and the attributes and attribute levels that together form alternatives that in turn form choice sets. A literature review was conducted to review what is already investigated in this area. The question that was aimed to answer here is: What has already been studied about the influence of the way of presenting the choice task in a stated-choice experiment on the results of that experiment? Table C.1 in Appendix C provides a non-exhaustive overview of studies that have investigated an aspect in this area.

3.2.1 Influence of the choice set attributes

The influence of various aspects related to the attributes of a choice set have been studied. Norman et al. (2016) investigated the effect of the order in which attributes are presented and found that this had little effect. Both Hensher (2006) and Rolfe et al. (2003) assessed the influence of the number of attributes that is included in the stated choice experiment. Both conclude that the number of attributes influences the results. There are also various studies on the influence of attribute level framing (Kragt & Bennett, 2011), for example of a risk-attribute (Vass et al., 2018; Veldwijk et al., 2016), of a discount-attribute (Gendall et al., 2006), of commercial deals (Smith & Sinha, 2000) and of benefit- and harm-related attributes (Howard & Salkeld, 2009). In the study of Vass et al. (2018), risk-communication did not have a significant influence on results. In all these other studies, attribute level framing did have a significant influence on the choices of respondents. It was also investigated whether displaying an attribute level in words or in graphics influenced results, which turned out to be the case (Veldwijk et al., 2015). Hence, we may conclude that different elements related to the presentation of the choice set attributes influence the outcomes.

3.2.2 Influence of the introduction to the choice options

In addition to the attributes, a stated choice experiment often contains an introduction that explains the choice option(s) and its attributes, for example an introduction to a hyperloop or an electric car. Currently, introductions of the choice options in stated choice experiments are mainly presented in the form of text, and sometimes a different medium is used, such as a video. Furthermore, the choice options are often explained as neutral as possible.

The purpose of the introduction
Stated choice experiments often contain non-existent products, services or systems that can be unfamiliar to respondents, such as a TPC system in this research. As a result, it is unknown to many respondents what this measure entails, while they are asked to make choices regarding the measure. In order to obtain valid data from a stated choice experiment, it is important that respondents are familiar with the subject on which they have to make choices. Choices made by respondents are then more consistent and predictive (Ben-Akiva, McFadden & Train, 2018). One reason for the fact that choices are less consistent and predictive when respondents are not or less familiar with the subject(s) of the choice task is that they are more uncertain about their preferences. When this is the case, respondents are more likely to use irrelevant information from the survey in making their choices. It is a way for respondents to cope with their uncertainty (Luchini & Watson, 2013). However, it may also be the case that respondents that are relatively unfamiliar with the subject are not uncertain about their choices, but that their preferences are unstable, since they may be different when they would be more familiar with the subject.

Training respondents can familiarize them with the unknown subject. This can for example be done with tutorials on the subject or with providing hands-on experience with it (Ben-Akiva et al., 2018). Respondents are also often familiarized with unknown subjects in stated choice experiments by means of an introduction to the choice options. This is a for example a text or video at the beginning of the survey that explains the product or system and discusses its various attributes. Research by Daamen et al. (2011) on carbon dioxide capture and storage (CCS) shows that opinions that were expressed by respondents after they had been informed on CSS were of higher quality in the sense that they were more stable and consistent and respondents were more confident about their choices. However, the study does not tell how it measured opinion stability, opinion consistency and opinion confidence.

Potential influence of the introduction
Familiarizing respondents by providing them with information on the subject they are unfamiliar with is thus a way to obtain more consistent and predictive choices. However, it can be expected that such an introduction can influence the preferences of respondents with regard to the subject. This is issue is also raised by Ben-Akiva et al. (2018) who discuss that respondents can for example see the wording of the introduction as clues for how they should feel about the introduced subject .

Contents of the introduction
No literature was found on the influence of the introduction on preferences of respondents. There were however studies found on the influence of the introduction on attitudes of respondents. Attitudes are different from preferences. Therefore it cannot be assumed that those results also apply to preferences of respondents. However, there may be similarities or relationships between attitudes and preferences, which may mean that preferences can also be influenced by the introduction. Therefore, what is already known about the influence of an introduction on attitudes is first discussed.

Studies show that different aspects of communication about a subject can influence the attitudes

of people on that subject. A message can influence attitudes by influencing 'beliefs about the qualities and characteristics of the attitude object' (Nelson & Oxley, 1999, p. 1040). It is very hard to create a neutral introduction (McFadden, 2017). The mentioning of certain information can be used as clues by respondents and induce unwanted cognitive responses, such as the starting point bias or the shaping effect (Sugden, 2005). Research also shows that framing the same information in different ways (for example 'lives saved' versus 'lives lost' and 'probability of surviving' versus 'probability of dying') can lead to different attitudes of respondents (Starmer, 2000; Tversky, & Kahneman, 1981). This is also shown by Molin (2005). His study shows that the way in which information on hydrogen is colored, for example by mass media who communicate about it, influences perceptions of hydrogen and indirectly influences attitudes about hydrogen and willingness to use it. Negative coloring of information had a larger negative effect on acceptance of hydrogen than positive coloring has a positive effect. This indicates that even balancing negative and positive information may not lead to the effects canceling each other out. Also the type of information that is given can influence attitudes. De Vries et al. (2014) showed that adding irrelevant information to a message can influence the attitude that is formed by the reader of the message. Furthermore, Cobb (2005) shows that the extent to which risks and benefits are described influences attitudes towards nanotechnology in this case. Research of de Vries et al. (2016) supports these findings by showing that emphasis framing can influence attitudes of readers. Emphasis framing means 'emphasizing advantages over disadvantages or vice versa' (De Vries et al., 2016). For example, people think more positively about CO2 capture and storage when the benefits are emphasized compared to when the risks are emphasized (De Vries et al., 2016). However, positive framing can also be experienced as manipulation, causing the reader to think more negatively about the subject (De Vries, 2017). That the same framing of information can have different effects shows how complex the influence of communication on attitudes is.

Based on these studies, it can be expected that the way in which a choice-option (for example TPC) is explained to respondents in the stated choice experiment can influence the attitudes of respondents towards that choice option in different ways. In stated choice experiments, we however measure preferences instead of attitudes. Since attitudes and preferences are different concepts, it is not clear whether the way in which a choice-option is explained to respondents also influences the preferences they indicate in a stated choice experiment. No studies could be found that investigate such influences of the introduction of the choice option(s) in the setting of a stated choice study.

Communication medium of the introduction

In addition to the content of the introduction, there is also the medium of communication. Text is a common way to introduce choice options in a stated choice experiment, but videos are also used nowadays. Videos are generally seen as more 'fun' and they require less effort from the respondent. In addition, videos are increasingly being used in other places, such as social media and blogs. As a result, respondents may be more accustomed to watching videos. Furthermore, you could expect videos to work better as an introduction tool than written text. Text must be actively read by respondents, which could result in respondents only scanning the text or even not reading it at all. Choi & Johnson (2005) compared video-based instruction and text-based instruction in the context of an online course. They investigated the influence on motivation and learning. They concluded that with video-based instruction the attention of people was higher than with text-based instruction. Therefore, a video may cause the respondent to take more of the information in than a written text does. Also, Baggett (1984) discusses how auditory and visual information are better for building mental models of a situation compared to linguistic information (Choi & Johnson, 2005). The brains of people absorb visual information faster than text and people remember visual information better. Therefore, information received via

a video might cause a person to remember information better compared to when it is received via written text. If there is more attention for a video and if information from a video can be better remembered by respondents, it is expected that using a video will influence the results of a stated choice experiment. Namely, respondents then might remember the explanation of, in this case, TPC better when they are asked to evaluate the choice sets.

However, it has not yet been investigated in stated choice studies whether using videos as the medium of introducing the choice options gives different results than the use of plain text. In the stated choice literature, no studies could be found on the effect of using video instead of text to introduce choice options. However, literature has been found about the use of pictures in choice tasks. It is considered an advantage of images that they can enhance realism and thereby increase the external validity of the results (Orzechowski, Arentze, Borgers, & Timmermans, 2005; Dijkstra, Roelen, & Timmermans, 1996). However, Patterson et al. (2017) state that there is no theory provided that supports this. A concern regarding the use of images is that they may include additional information that is not controlled by the experimental design that may influence choices of respondents (Patterson et al., 2017; Molin, 2011; Jansen et al., 2009). This is however mainly a concern when pictures of existing objects, e.g. houses, are used. This is expected to be less of a problem in this study, where an animated video is used to explain TPC. It is however possible that certain ways of visualizing the system influence people. Furthermore, also a study was found that showed that presenting information in a text or in a tabular format in a stated choice experiment influenced the estimated preferences (Hoehn et al., 2010). This illustrates that presenting the same information in different ways can influence results. This might also be the case when presenting the same information in a written text or in a video.

Based on all of this, it can be expected that stated choice studies give different results based on whether text or video is used to introduce the subject.

3.2.3 Knowledge gaps

Previous studies found that the way in which the attributes are presented influence the outcomes of stated choice experiment, but, to my best knowledge, the influence of the introduction of choice options have not been studied. Many stated choice studies regarding the topic of road pricing do not even report the introduction that was used in the experiment (e.g. Jaensirisak et al., 2005; Kockelman & Kalmanje, 2005; Jakobsson et al., 2000). It can be expected that the introduction affects preferences of respondents.

Influence of the content of the introduction
When reviewing stated choice studies, it was noted that researchers make different choices in the type of information they include in the introduction of policy measures. Roughly, two types of information could be distinguished:

1. Only an explanation of how the measure works, as neutral as possible;
2. Explanation of how the measure works, and information on the underlying problem that the measure should reduce.

For example, Raux et al. (2015) only explain how a credit system for fuel consumption works in their introduction and Bristow et al. (2010) just explain how carbon tax and personal carbon trading work. Gevrek & Uyduranoglu (2015) on the other hand discuss in detail the reason for a carbon tax and the urgency of the measure in their introduction of a carbon tax. It is unknown whether these two types of explanations of the same subject in a stated choice experiment will lead to different results.

Influence of the medium of communicating the introduction
Research into the influence of different forms of communication in the introduction of choice options in stated choice experiments is lacking. A first step in filling this knowledge gap is to investigate whether there is any effect and what this size of this effect is. This exploratory step will be taken in this study. If this research shows that the effect occurs, an important follow-up step is examining which mechanisms cause the occurrence of this effect. This will however not be part of this research.

4

The design variables of a Tradable Peak Credits system

Since a TPC system does not yet exist, there is also no clear definition of a TPC system. Several designs of a TPC system are possible. This section provides an overview of design variables of a TPC system. In this research, a design variable is defined as an aspect of a system that can be designed in different ways and that (partly) determines how the system functions.

The design variables are identified via three methods. First of all, it was reviewed which design variables are identified in different studies. Furthermore, focus groups held by Krabbenborg (Krabbenborg et al., 2019) are used to supplement and enrich this overview. Finally, experts were consulted to complete the list. As discussed in Chapter 3, there is a limited amount of papers available that specifically discusses tradable peak credit systems. Therefore, literature on other types of personal tradable credit systems was also used to identify design variables. More specifically, literature on tradable driving credit systems and personal tradable emission credit systems was used. Due to the fact that all these systems include some form of personal tradable credits, certain design variables of these systems are also relevant to TPC systems. Some studies explicitly mention and discuss design variables of a tradable credit system, in other studies it could be derived that some aspect of the system is a design variable.

The identified design variables are explained in the remainder of this section. To give this more structure, categories of design variables have been distinguished. Variables that relate to a certain aspect of the TPC system are placed within one category. The following categories are distinguished: applicability of credits, characteristics of credits, distribution of credits, trading of credits, and management of credits.

4.1 Applicability of credits

Geographic area of applicability of credits
It must be determined in which geographical area credits are needed to consume a scarce resource (Raux, 2007; Grant-Muller & Xu, 2014; Verhoef, 1997; Tietenberg, 1980). The scope of this area can be very diverse: it can for example be only a specific bridge for which credits are required, but it can also involve all highways in the Netherlands, or a subset of highways

in a certain area such as the Randstad. The choice for this area depends on where there is a desire to reduce congestion.

Peak and off-peak periods
This research focuses on peak credits. In off-peak periods, credits are not required. It must therefore be determined what periods of the day are considered peak periods and what periods are considered off-peak periods.

Target group of credits
The group of people who need credits to drive in a specified area is the target group of the credit scheme (Stevens & Verhoef, 2013; Tietenberg, 1980). Stevens & Verhoef (2013) discuss a TPC system with commuting employees as the target group, since they often drive during rush hours. Most tradable driving credit systems in literature however target all road users. By targeting all traffic with this system, there is more control over the amount of traffic that is allowed at a certain location during peak hours. This increases the effectiveness of the TPC system.

Policy for foreign vehicles
If foreign cars that occasionally use Dutch roads not belong to the eligible recipients of free credits, it must be determined what policy applies such incidental users (Raux, 2007). The first option is to let them use the road during peak hours without the need for credits. An advantage of this is that this avoids barriers for visiting the Netherlands, while a disadvantage is that the amount of cars can then exceed the cap set by the government, which reduces the effectiveness of the TPC system. A second option is that foreign vehicles have to buy the required credits on the market. This is probably perceived as more fair than the previous option by the Dutch population.

4.2 Characteristics of credits

Method to create differentiation within the credit scheme
The actual time and place of driving determine the emergence of congestion within a geographic area (Verhoef, 1997). By differentiating according to place and time within the credit scheme, there is more control over the amount of cars that can drive at a certain place at a certain time. Hereby, congestion can be reduced more effectively. Verhoef (1997) and Fan & Jiang (2013) both distinguish two ways to create this differentiation: (1) time-place specific credits and (2) time-place dependent credit rates. Option 1 'restrains the consumption of the credits within certain time and place' (Fan & Jiang, 2013). This means that credits are only valid in a certain place, in a certain period. With option 2 there is one general credit that applies everywhere, only the number of credits you have to pay depends on the place and time of driving.

If option 2 is chosen, time- and place dependent rates must be determined. If option 1 is chosen, the degree of specificity in time and place must be determined. The degree of place-specificity is high when many geographical zones with their own credits are distinguished. Then, for example, you need a different credit for each highway. The degree of time-specificity relates to the period of validity of a credit, which is also discussed as a separate design variable. This degree is high when credits are valid for a short period of time. Then, for example, a credit is only valid for a specific date. There might be an important trade-off present here between effectiveness and effort for the user. If credits are more specific in terms of time and place, I would intuitively expect them to be more effective at reducing congestion. For example, if credits are valid for a week, everyone can still use their credit on Tuesday with the undesirable effect of causing large traffic jams on Tuesday. If credits on the other hand are only valid for a specific date, it is exactly known how much traffic drives on a certain day during peak

hours. However, if credits are more specific, participants will have to trade more to obtain the right credits, which requires more effort from them. The practical feasibility of working with time-place specific credits therefore strongly depends on the degree of specificity. If the degree of specificity is too high, then trading of credits to obtain the right credits for a trip becomes too complicated for road users (Fan & Jiang, 2013).

Period of validity of credits
The period of validity of credits concerns the time period in which a credit is valid. For example, a credit can be valid on a specific date, for example 8 March. The owner can then only use this credit to make a ride during the rush hour on 8 March. A credit can also be valid for a longer period, such as a week or a month. Then the owner of a credit that is valid in the month of June can decide for himself on which day in June he will use the credit.

Units of credits
It must be determined what unit a credit represents. Several authors discuss this (Verhoef, 1997, Fan & Jiang, 2013, Grant-Muller & Xu, 2014, Dogterom, 2017, Raux, 2007) and the options are summarized by Fan & Jiang (2013): weekdays per week, trips, vehicle-miles traveled (VMT), fuel consumption, monetary access allowance ('monthly allowance of monetary travel credits') and time-place specific access allowance. Fan & Jiang (2013) discuss which of these options are most suitable to reduce congestion. This depends on their 'accuracy of quantifying roadway capacity'. Time-place specific access allowance is most suitable, followed by VMT, trips and weekdays. The other two measures only 'indirectly quantify roadway capacity' (Fan & Jiang, 2013). However, there is a trade-off with costs here, since the options that have a higher accuracy also involve higher costs.

4.3 Distribution of credits

Way of allocating credits
Three methods of allocating credits have been distinguished (Grant-Muller & Xu, 2014; Fan & Jiang, 2013; Raux, 2007; Verhoef, 1997; Tietenberg, 1980). In the first method, the government allocates as many credits as would be required for road use before the credit system was introduced. The government then repurchases credits to reduce road use. This method applies a 'government-pays' principle. The second method applies a 'polluter-pays' principle: people have to buy credits to drive during rush hour. The third option is a middle way, also known as 'grandfathering': the amount of road traffic that the regulator wants to allow (the target) is translated into the corresponding number of credits, and these credits are distributed among eligible recipients free of charge.

Eligible recipients of free credits
If credits are allocated to people free of charge, it must be determined who the recipients are (Dogterom, 2017; Grant-Muller & Xu, 2014; Fan & Jiang, 2013; Stevens & Verhoef, 2013; Raux, 2007; Kockelman & Kalmanje, 2005). Fan & Jiang (2013) discuss that credits can be attached to vehicles or people, and that most systems proposed in literature attach them to people. By attaching them to vehicles, an incentive could be created to buy additional vehicles in order to receive more credits. When credits are issued to individuals, different groups can be chosen. Most frequently mentioned options are car owners, licensed drivers, taxpayers or (adult) residents.

An important choice is whether credits will also be granted to people who currently do not or hardly contribute to congestion. Motorists can earn money under a TPC system by showing the desired behavior. It can be considered unfair if people who already show the desired behavior cannot benefit under the TPC system. This is a reason to not only distribute credits among

car owners. However, this would imply that existing peak drivers receive fewer credits and that the system thus has more impact on them. This could lower the acceptance among motorists who are currently driving at rush hours. On the other hand, it can be expected that it will increase acceptance among people who do not drive at rush hours. Raux (2007) expects that the acceptability is higher when not only car owners, but all residents receive credits.

Distribution principle
The distribution principle is the way in which the total amount of available credits is divided among all eligible recipients of free credits. A distinction can be made between two principles: uniform distribution among all recipients, or non-uniform distribution, whereby the distribution depends on certain characteristics of recipients (Dogterom, 2017; Grant-Muller & Xu, 2014; Bristow et al., 2010; Kockelman & Kalmanje, 2005). When choosing the non-uniform distribution, the distribution can depend upon different characteristics of recipients.

- Historic car-use: recipients who have driven more in the area in the past receive more credits (Dogterom, 2017);
- Work travel needs: recipients who have to drive the relevant route between home and work receive more credits (Dogterom, 2017; Grant-Muller & Xu, 2014);
- Car ownership: recipients who own a car receive more credits than recipients without a car (Bristow et al, 2010). This option is of course only possible if people without a car also belong to the eligible recipients;
- Employment: recipients who have a job receive more credits than the unemployed;
- Income: recipients who have a lower income receive more credits than people with a higher income.

Of course, even more options can be thought of.

Credit allocation interval
The credit allocation interval entails how often credits are distributed by the government to all eligible recipients of free credits (Aziz et al., 2015). For example, credits could be distributed each week or each month. The choice for the allocation interval partly depends on the 'period of validity of credits'. For example, if credits are valid for a month it is not obvious to hand them out weekly. If credits are valid for a specific date, then different allocation intervals are possible.

Cap
If the grandfathering method of allocating credits is applied, eligible recipients will receive a free allowance of credits per time interval. The total amount of available credits per time interval, the cap, will be determined by the government (Aziz et al., 2015; Grant-Muller & Xu, 2014; Fan & Jiang, 2013). This is done by determining how much traffic is allowed in a certain area and translating this into the number of peak journeys that can then be made. The amount of credits recipients receive is therefore partly determined by the amount of traffic reduction that is desired. It is also influenced by the distribution principle.

4.4 Trading of credits

Trading parties
Fan & Jiang (2013) observed two options in terms of between whom the trade in credits takes place. The first option is that people resell unused credits back to the scheme operators. The second option is that people buy and sell credits among each other, possibly through an intermediary. If people can trade credits among themselves, how do they find each other?

How do they find someone who sells a credit they need and how do they find buyers for their own credits? And how do they negotiate a price? Relatively little attention is paid to this in the literature (Fan & Jiang, 2013). This procedure of finding trading partners and reaching an agreement determines to a large extent how much effort the system poses for participants. Focus groups held by Krabbenborg (Krabbenborg et al., 2019) show that this is a very important aspect for potential participants, and it is expected that this will strongly influence their opinion on the system. Brands et al. (2019) also acknowledge the disadvantages of consumer directly trading with each other in terms of having to search for traders and having to negotiate a price which creates transaction costs. They therefore propose to let people trade with an intermediary.

Market operation
The market operation is defined as the way in which the price of a credit is determined. Research shows that there could be either a fixed price for a credit, or the price could be determined by the market (Dogterom, 2017; Raux et al. 2015; Grant-Muller & Xu, 2014; Fan & Jiang, 2013; Xiao et al., 2013; Bristow et al., 2010; Raux, 2007; Verhoef, 1997). If the price is determined by the market, there could be a price ceiling or not. A price ceiling can prevent excessive price rise and guarantee affordability of credits (Raux, 2007).

Trading possibilities
It must be determined what is allowed regarding the trading of credits. If trading takes place through an intermediary, for example a trading platform, then it must be determined whether it is also permitted to sell or give credits directly to others, not via the trading platform (Grant-Muller & Xu, 2014; Stevens & Verhoef, 2013; Bristow et al., 2010). Grant-Muller & Xu (2014) note that if this is not permitted, a black market might arise. However, this can perhaps be made impossible by properly designing the system.

Purchase limits
In research on personal carbon trading, limits on the purchase of carbon credits are considered (Bristow et al., 2010). Reason for such a limit is the avoidance of excessive use of such credits by individuals. With peak credits, a purchase limit can also be considered. The main reason for this is to prevent speculation (Brands et al., 2019). It is undesirable that credits can be purchased in large quantities, thus creating scarcity to drive up the price of credits. On the other hand, a purchasing limit can be seen as a restriction of freedom. Brands et al. (2019) propose to limit people to owning an amount of credits that they could use themselves. So if for example a person can make ten rush hours trips in a week and needs one permit for each trip, he should only be allowed to own ten credits at the start of the week. As the week progresses, this amount should decrease based on the amount of rush hour trips he can still make.

Credit price fluctuation
Potential users find it important that the price of a credit does not fluctuate too often, according to focus groups held by Krabbenborg (Krabbenborg et al., 2019). However, the advantage of having the price fluctuate more often is that the price changes will be more gradual. Even if the price will be determined by the market, it is possible that the price will only be updated once in a certain time. How often the price fluctuates per unit of time can therefore be determined.

4.5 Management of credits

Credit scheme operator
A regulator must be given the responsibility to manage the TPC system. Such a regulator would, among other things, be responsible for distributing credits, the system that automati-

cally deducts credits from accounts and the trading platform on which credits are traded. A government agency could be the regulator, but it is also possible to leave it to a private party.

Monitoring

It must be determined which technology is used for the monitoring that is required to operate the system. It must be registered which credits people have in their possession and who makes a drive during rush hours in the area for which credits are required. It must then be checked whether they have a valid credit and it must be registered that this credit has been used. Technologies to achieve this already exist, such as smart cards and radio transmitters that are installed in cars (Grant-Muller & Xu, 2014). In the choice for a technology, aspects such as reliability of the technology and privacy impact must be taken into consideration.

Enforcement

If people from the target group do not have a valid credit for a rush-hour ride, they are in violation. A logical choice is to let the system purchase a credit for this driver automatically. This prevents that more cars are driving during peak hours than credits issued. It is possible to impose an additional fine to these drivers to discourage them from driving without a valid credit.

5

Design of the survey and the stated choice experiment

A digital survey was conducted to collect data. A stated choice experiment was part of this survey. The stated choice experiment was conducted on the one hand to elicit the public's preferences regarding a TPC system and on the other hand to analyze the influence of the introduction in a stated choice experiment on outcomes of the survey. This chapter explains how the survey and the stated choice experiment were designed. First the approach to designing the survey is discussed in Section 5.1. Next, an overview of the components of the survey is given in Section 5.2. Subsequently, Section 5.3, 5.4 and 5.5 discuss the design of these different components. Finally, Section 5.6, section5.7 and 5.8 discuss the population and sample of the survey, the ethical considerations and the pilot survey respectively. The entire survey can be found in Appendix I. The survey was constructed with the software SurveyGizmo.

5.1 Design approach

A first version of the survey was made in which about ten possible attributes for the stated choice experiment were included. The survey was then iteratively improved. It was also iteratively determined which design variables from Chapter 4 are varied as attributes in the stated choice experiment and which design variables are fixed. The survey was presented to Bert van Wee and Nico Dogterom. Based on these conversations, the survey has been improved and attributes and levels have been selected for the stated choice experiment. Subsequently, the survey was submitted to Bert van Wee, Paul Koster, and Erik Verhoef, and again improved based on this. Then, a pilot of the survey was held to receive feedback from people who are not familiar with the subject since the target group of the survey will largely also not be familiar with TPC.

5.2 Structure of the survey

This survey consisted of the following components:

- Welcome text
- Introduction to tradable peak credits and its attributes (Section 5.3)

- Stated choice experiment (Section 5.4)
- Questionnaire (Section 5.5)

5.3 Introductions to tradable peak credits

Before respondents were asked to indicate their preferences about TPC systems in the stated choice experiment, TPC was first explained to them. TPC is a new measure, so respondents are probably not familiar with it. It is also a fairly complex measure that requires clear explanation. The introduction to TPC contained the following information:

- The fixed characteristics of TPC (Section 5.3.1)
- The attributes and levels that are varied in the stated choice experiment (Section 5.4.1)
- Some additional information (Section 5.3.2)

Section 5.3.3 discusses the guidelines that were followed in writing this introduction. The introduction was iteratively improved based on feedback of road pricing scientists (see Appendix D) and feedback of the pilot survey (see Section 5.8). Furthermore, four versions of this introduction were made, which is further explained in Section 5.3.4.

5.3.1 The fixed characteristics of the TPC system in this research

As discussed in Chapter 4, several designs of a TPC system are possible. Therefore it still had to be decided what the TPC system is this study entails. A choice has therefore been made for a number of design variables, and these choices together form the fixed characteristics of the TPC system that is being investigated in this study. These fixed characteristics of TPC are explained to respondents in the survey. This should prevent them from making implicit assumptions about these characteristics which affect their preferences with regard to TPC. Other design variables are not yet fixed and are varied as attributes in the stated choice experiment. Section 5.4.1 discusses the choice for these attributes.

This section now presents which design variables are fixed by giving a short description of what is considered a TPC system in this study. The choices for this are substantiated in detail in Appendix M. The choices were made based on conversations with Lizet Krabbenborg and the consulted road pricing scientists. For clarity: these choices do not have to apply to every TPC system, but do apply to the TPC system that is presented in the stated choice experiment of this study.

The fixed characteristics of the TPC system in this study are the following. All passenger cars need valid credits to drive on all highways and N-roads in the municipality of Amsterdam (or Utrecht) during peak hours on weekdays. Peak hours are from 07:00 - 09:15 and from 16:00 - 18:15. Every peak credit represents one trip during peak hours. The government determines how many credits are issued, and these are distributed free of charge to all eligible recipients according to a certain distribution method. Participants have a personal account to manage their credits and there is a system that ensures that credits are automatically deducted from your account when making a drive during peak hours. Credits can be traded by their owners on a trading platform. It will also be possible to buy credits in stores. The price of a credit is determined by supply and demand. The maximum price of a credit is €6,-. There is a purchase limit to prevent speculation: people can not have more credits than they can use themselves. If people without a valid credit drive during rush hour, they receives a notification to buy a credit. If they do not do this, the system will automatically purchase a valid credit for that ride

for the market price plus transaction costs of €1,-. The government introduces and manages the TPC system.

5.3.2 Additional information in the introduction

Next to the fixed characteristics of TPC discussed in Section 5.3.1, some additional information is included in the introduction of TPC to respondents. This information is included since it is expected that this information will influence the preferences of respondents regarding TPC. It is undesirable that respondents make implicit assumptions regarding this information and base their answers on it.

Credit price
It is important that people know what the price of a credit approximately will be, since it is expected that this price can strongly influence people's opinion about TPC. It is undesirable for respondents to make assumptions themselves and, for example, expect the price to be much higher than it will be. Therefore a price range was given. It is not yet known what a realistic price range for this system is. Therefore an educated guess had to be made. In Stockholm where congestion charging is implemented, the price to enter central Stockholm during peak hours is between €2.30 and €3.30. It was expected that the price range of a credit would be approximately the same. This estimation was submitted to Erik Verhoef, and he advised to adjust the estimate to €2,- - €4,-. So, in the introduction of TPC respondents were told that the price of a credit is expected to be between €2,- and €4,-.

Required reduction in cars
It is explained by what percentage the current amount of car journeys must be reduced in order to resolve most traffic jams, namely 10%. This gives respondents an an indication of how much they will have to reduce their number of car trips when TPC is introduced. This information is included since it is expected that this will influence their opinion about TPC.

Effectiveness of the TPC system
It is expected that the extent to which TPC would reduce congestion influences whether respondents prefer the introduction of TPC over maintaining the current situation. It is unknown how much congestion would be reduced by the studied TPC system. Erik Verhoef, one of the consulted road pricing scientists was asked to make an educated guess for this. He estimated that the delay caused by traffic jams would decrease by 25% or more.

5.3.3 Guidelines for the introduction

The introduction of TPC to respondents in this study is very important because a good understanding of TPC is crucial for obtaining valid data from the stated choice experiment. Because TPC is a complex and new system, a major challenge was explaining TPC in such a way that respondents understand it, but that the length of the introduction not causes respondents to drop out. The following principles have been followed when formulating the introduction of TPC:

- The use of simple language.
  Since all adults, regardless of foreknowledge, age and education level, must understand TPC, it has been decided to keep the language as simple as possible.
- Include as little irrelevant information as possible.
  De Vries et al. (2014) showed that adding irrelevant information to a message dilutes the impact of the relevant information. In addition, adding unimportant details makes the introduction longer, which may increase the chance of respondents dropping out.

Respondents from the pilot survey indicated that they thought the introduction was long and that they therefore may drop out. They made suggestions of information that could be omitted.

- Only include information that would also be available in reality.
  In order to make the choice task in the stated choice experiment as realistic as possible, and to prevent a hypothetical bias as much as possible, it is important to only include information that people would also know in reality when they would be asked to vote for a new measure.

5.3.4 Versions of the introduction

As discussed in Section 2.4, four versions of the introduction to TPC were made and each version was presented to a quarter of the respondents. Figure 5.1 shows the characteristics of the four versions. The versions with 'Explanation TPC' only provide an explanation of how a TPC system works. The versions with 'Explanation TPC & problem' include the exact same explanation, but in addition provides information on the underlying problem that a TPC system should reduce: the congestion problem. The following specific information is added to the introduction:

- The problem that TPC should reduce: congestion;
- The impact of congestion on individuals: longer travel times and uncertainty about travel times;
- The impact of congestion on society: financial damage.

This is expressed in the following sections that were added in the versions with 'Explanation TPC & problem':

There are often traffic jams on weekdays in the Netherlands. It is expected that the number of traffic jams will increase in the coming years if no measures are taken. These traffic jams cost drivers time and create uncertainty about their travel times. Traffic jams are also bad for the economy, since it costs money if trucks or employees are standing still on the highway or have to make a detour. If the traffic jams continue to increase, the financial damage will continue to increase.

Researchers expect peak credits to reduce traffic jams considerably, as the distribution of credits gives control over how many cars can drive during rush hour. This means that drivers are less often in traffic jams and therefore have less time loss and uncertainty about their arrival time.

The full introduction texts used in the survey can be found in Appendix E.

In version 1 and 3, the information was not presented in text, but in an animation video with a voice-over and subtitles.

The survey also included a manipulation check. At the end of the survey, respondents were asked whether they read about the negative consequences of traffic jams in the introduction of TPC (information that was only part of 'Explanation TPC & problem'). They could answer 'yes', 'no' or 'I do not remember'. Respondents do not always read the entire introduction. This question is added to check whether respondents actually read the information in the introduction that was varied.

Introduction version 1 -Explanation TPC -Video	**Introduction version 2** -Explanation TPC -Text
Introduction version 3 -Explanation TPC & problem -Video	**Introduction version 4** -Explanation TPC & problem -Text

Figure 5.1: Introduction versions

5.4 Stated choice experiment

This section will discuss the construction of the stated choice experiment. First the selection of attributes and levels that are varied in the choice sets will be substantiated. Then it is explained how the choice sets were constructed. Next, it is discussed which questions are asked to respondents in the choice sets.

5.4.1 Selection of attributes and levels

The attributes and levels selected for the stated choice experiment are given in Table 5.1. This selection was made based on the literature study from Chapter 4, the focus groups held by Krabbenborg (Krabbenborg et al., 2019) and the consultation of road pricing scientists (see Appendix D). This section will discuss the selected attributes: what is its definition, why is it selected and what levels are included and why? Guidelines for selecting attributes were the following:

- It must be expected that the attribute influences the public opinion about the system;
- The attributes must concern fairly fundamental choices with regard to the TPC system. It is useful to first investigate the most fundamental characteristics of TPC, and at a later stage investigate design choices that concern a more detailed level. For example, the attribute 'trading possibilities' (see Chapter 4) was considered too detailed for this stated choice experiment.

Eligible recipients of free credits
Eligible recipients of free credits are the people who periodically receive free credits. The distribution issue (how are free credits distributed and to whom) is a very essential issue in the design of a TPC system. It concerns very high-level and fundamental choices that must be made if TPC were introduced. Consulted road pricing scientists indicated that this issue will strongly determine how fair people think the TPC system is. It is therefore expected that this attribute will strongly influence whether people prefer this system over the current situation.

A logical first option is to give free credits to all residents of the area where TPC is introduced. It is also possible to not only give credits to residents, but also to people who work but not live in the area where TPC is introduced. It must furthermore be decided whether all people receive credits, or only car owners. When giving credits to all people, also people who already show the desired behavior by not driving during peak hours can benefit from the system.

Distribution principle
The distribution principle is the way in which the total amount of available credits is divided among all eligible recipients of free credits. This is the second component of the distribution issue. Here too, consulted road pricing scientists indicated that this aspect is likely to have a strong influence on the opinion of people with regard to TPC.

A distinction can be made between two principles: uniform distribution among all recipients, or non-uniform distribution, whereby the distribution depends on certain characteristics of recipients. The first level is therefore equal distribution among all recipients. The other levels have an uneven distribution based on various aspects. Historical car use is an option suggested in the literature. One level is therefore a distribution based on how many kilometers someone has driven in the past in peak hours the area where credits are needed. Another option is to give more credits to people who work more hours, since it can be expected that people who work more hours have to drive more often. The fourth level included is distribution based on income. It is sometimes suggested in literature to also use the TPC system as a wealth distribution tool by giving people with a lower income a bit more credits. Distribution of credits based on whether someone has a car has also been suggested in literature. However, it was decided not to include this level in this study, since there are levels of 'eligible recipients of free credits' where only people with a car receive credits. These levels combined with a distribution based on car ownership does not make sense.

Credit allocation interval

The credit allocation interval entails how often free credits are distributed among eligible recipients of free credits. In this study, it is assumed that credits issued in an interval are also valid in the entire interval. So, if the interval is long, credits are also valid for a long period. The length of this interval may influence how effectively TPC can reduce congestion. Intuitively, if credits are valid for a shorter time, there is more control over achieving the desired distribution of traffic. An example: if credits are only valid for one day, it is known exactly how much traffic there is at a maximum that day. However, if credits are valid for one year, a lot of credits can be used on one day, causing congestion. So, short intervals may make the system more effective in reducing congestion. However, there is no research yet that confirms this and that shows the required credit allocation interval.

It is however interesting to find out to what extent this interval influences people's preference for this system. Namely, focus groups held by Krabbenborg (Krabbenborg et al., 2019) revealed that people are afraid of the 'hassle' of TPC. With a short interval, for example a week, most people will have to trade credits every week, while with a longer interval, for example a month, people may only have to trade the last week of that month. Shorter intervals can therefore give more 'hassle' to people. By including this attribute in the stated choice, insight can be gained to what extent this interval influences the preference of people for TPC compared to the current situation.

Different allocation intervals are possible. Based on the literature, it is expected that issuing credits for specific days is not practically feasible. Long credit allocation intervals are also not realistic for this system. Therefore, a week and a month were chosen as levels. Consultation of experts confirmed these as realistic levels. These are also intervals mentioned by Brands et al. (2019).

Credit price fluctuation

The credit price fluctuation entails how often the price of a credit on the trading platform fluctuates. The price is determined by supply and demand, but it is possible to only update the credit price every once in a while. Potential users find it important that the price of a credit does not fluctuate too often, according to focus groups held by Krabbenborg (Krabbenborg et al., 2019). Nico Dogterom also expects that people do not like too much fluctuation, based on the fact that people find variable information and uncertainty difficult. This attribute was selected to ascertain to what extent this price fluctuation influences the preference of people for this system compared to the current situation.

Since one credit allocation interval level is weekly allocation of credits, it is not realistic that

the credit price would only be updated weekly. Therefore all credit price fluctuation levels are fluctuation happening more often than weekly. Two levels have been chosen: on the one hand almost real-time fluctuation by having the price change every minute, on the other hand a fairly fixed price by having the price change only once a day.

Table 5.1: Summary of characteristics TPC system in this study

Attribute	**Levels**
Credit allocation interval	Weekly Monthly
Eligible recipients of free credits	All residents of the municipality. All residents of the municipality who own a car. All residents of the municipality + people who work there. All residents of the municipality + people who work there and own a car.
Distribution principle	Credits are equally distributed among all recipients. People who have traveled more km will receive more credits. People who work more hours per week receive more credits than people who work less hours per week. People with a lower income receive more credits than people with a higher income.
Credit price fluctuation	Every minute. Every day.

5.4.2 Construction of choice sets

In order to construct the alternatives that will form the choice sets, an experimental design is required. An experimental design outlines which attribute levels must be combined into alternatives. It also shows which alternatives should be combined into choice sets.

Choice for an orthogonal fractional factorial design

First a type of experimental design to use was selected, since different types exist. The first type is a full factorial design. This means that all possible combinations of all attributes levels are constructed (Hensher et al., 2005). This often results in (too) many choice sets for the respondents to evaluate. For this research, this would result in 64 alternatives. These are too many alternatives for respondents to evaluate. The second type of experimental designs, fractional factorial designs, allows to reduce the number of alternatives (Hensher et al., 2005). There are three types of fractional factorial designs: (1) random designs, (2) orthogonal designs and (3) efficient designs. With a random design, a fraction of the full factorial design is randomly selected. A disadvantage is that this design is that there will be correlations between attributes. This leads to higher standard errors of parameter estimates, which means that the parameters are less reliable. With orthogonal designs, the correlations between attributes are zero. An orthogonal design is therefore prefered compared to random design. In an orthogonal design, dominant alternatives can occur, which is undesirable because they do not provide information about trade-offs the respondent makes. Efficient designs can tackle this problem. This design is built in such a way that it maximizes the information about trade-offs and minimizes standard errors of parameters. However, it can not be determined in this study which alternatives will be dominant, since there are no attributes for which we can be certain that all respondents have the same preference (such as with a price attribute). Therefore, one of the main reasons to use an efficient design does not apply in this study. Furthermore, prior

information on parameter estimates is required to be able to generate an efficient design. It is important that the priors are correct, because wrong priors can lead to biased parameters. In this research, the magnitude and sign of priors for the attribute levels are unknown. It is possible to estimate these priors based on a pilot study. It was however decided not to use an efficient design, since it requires additional work while the advantage of using an efficient design compared to using an orthogonal design is limited. An orthogonal fractional factorial design was therefore chosen.

The experimental design
The software package Ngene was used to obtain an experimental design. An orthogonal fractional factorial design was used to construct twelve alternatives. Sequential construction was then used to combine alternatives into choice sets. An advantage of sequential construction compared to simultaneous construction is that it results in less choice sets (Choice Metrics, 2018). A disadvantage is that there will arise correlations between the alternatives in a choice set. But since the choice sets consist of two TPC system alternatives with the same attributes, each attribute appears twice in a choice set. This makes the correlations between alternatives in a choice set not too problematic.

It was chosen to have two alternatives per choice set. This was also the case in the pilot and it appeared that people already found this choice complex. Therefore it seemed inappropriate to make this choice even more complex by increasing the number of alternatives.

Since evaluating twelve choice sets is expected to be too exhausting for respondents, the choice sets were divided in two blocks. A blocking column was used to allocate choice sets to the blocks. Each respondent was presented one block of six choice sets. The individual blocks are not orthogonal, but they are attribute level balanced (Choice Metrics, 2018). The experimental design obtained with Ngene is shown Appendix H.

5.4.3 Questions regarding the choice sets in the survey

Figure 5.2 shows an example of one of the choice sets as presented to respondents in the survey. Two questions are asked to the respondent after each choice set:

1. Which TPC system do you prefer?
2. What would you vote, pro or con the introduction of the TPC system of my preference?

In order to gain insight into the extent to which the introduction of TPC is preferred compared to maintaining the current situation, respondents must be able to indicate this preference. A first option is to add an alternative to each choice set that represents the current situation. Then each choice set consists of three alternatives for which respondents indicate their preference: two TPC systems and the current situation. A disadvantage of this method is that there is a chance that a large part of the respondents opt for maintaining the current situation. This chance is plausible, as TPC is still a relatively unknown system and since people might simply not like the system. If this happens, there may be too little choice data available to analyze preferences regarding design variables of TPC systems. Therefore, another method was chosen. The respondent is first asked to make a choice between two TPC systems. Secondly, the respondent is asked to indicate whether he would vote for or against the introduction of the TPC system of his preference. If too many respondents choose to maintain the current situation, then choice data is still available to gain insight in the preferences regarding the design variables. It was chosen to ask the question like it would be done in a referendum, in order to make the choice situation as realistic and concrete as possible for respondents. It is possible for authorities to gather citizens' opinions in such a way. By making the choice task more realistic, it is expected that the collected choice data is more valid.

	Peak credits system 1	Peak credits system 2
How often are credits distributed?	Weekly	Monthly
Who receives credits?	Residents + employees Amsterdam	Residents + employees with car Amsterdam
How are credits distributed?	Equal distribution	People with a lower income receive more credits
How often does the credit price change?	Every minute	Every day

Which peak credits system do you prefer? *

- ◯ Peak credits system 1
- ◯ Peak credits system 2

What would you vote for? *

- ◯ In favor of the introduction of the tradable peak credits system I have chosen
- ◯ Against the introduction of the tradable peak credits system I have chosen

Figure 5.2: A choice set as presented in the survey, translated

5.5 Questionnaire

In order to answer RQ 1.2 and thus analyze the relation between certain variables and the preference for the introduction of TPC, these variables need to be measured in the survey. Various statements and questions have been constructed to do so. A selection of variables that is included in this study is made based on the literature discussed in Section 3.1.4. There are four categories of variables included: socio-demographic variables, mobility habits, attitudes on TPC and attitudes on car use. The questions asked regarding the socio-demographic variables and mobility habits can be found in the copy of the survey in Appendix I. The way in which the attitudes on TPC and car use are measured is more complex and therefore explained in a separate section, Section 5.5.1. Section 5.5.2 substantiates how the preference for TPC over congestion charge and kilometer charge is measured in order to answer RQ 1.5.

5.5.1 Measuring attitudes on TPC and attitudes on car use

To answer RQ 1.3, the attitudes on TPC and on car use are measured using statements. Summated scales are used for part of the attitudes. This entails that multiple statements are used to measure one underlying attitude. The scores on those statements are summed to arrive at a single score for that attitude for a certain respondent (Santos, 1999). A condition for constructing such a summed scale is that the scale is reliable. Whether this is the case is checked with a reliability analysis in which the Cronbach's Alpha of the scales is determined. The rule of thumb is that a scale is reliable if the Cronbach's Alpha is greater than 0.7 (Santos, 1999).

Validated statements have been sought in the literature. The advantage of working with validated statements is that it is already known that these statements together form a reliable scale. For two attitudes, 'perceived fairness' and 'expected personal outcome' validated statements were found in literature. For the other attitudes, suitable validated statements were not found, so statements were drawn up.

There was a trade-off between the length of the survey and the benefits of having multiple

propositions per attitude. Because the survey became so long that it was feared that many respondents would drop out, it was decided to include fewer statements. That is why only for the attitudes that I expect to have the most influence on the opinion of respondents about TPC multiple statements are included. Also this amount was limited to two statements per attitude. The other attitudes were directly measured with one statement. A overview of the statements per attitude is given in Table 5.2.

Table 5.2: Operationalisation of attitudes on TPC and attitudes on car use

Attitude	**Operationalisation**	**Source**
Perceived fairness (1)	How honest do you find tradable peak credits for yourself? a	Sun et al., 2016
Perceived fairness (2)	How honest do you find tradable peak credits for others? a	Sun et al., 2016
Perceived effectiveness congestion (1)	I think tradable peak credits reduce traffic jams. b	
Perceived effectiveness congestion (2)	How effective do you think peak credits reduce traffic jams? c	
Perceived effectiveness environment	I think that tradable peak credits reduce the impact of car use on the environment. b	
Perceived complexity (1)	I find tradable peak credits easy to understand. b	
Perceived complexity (2)	I find peak credits very complicated. b	
Perceived infringement on freedom	I view tradable peak credits as an infringement on the personal (mobility) freedom. b	
Perceived infringement on privacy	I think tradable peak credits will violate the privacy of people. b	
Expected personal outcome (1)	I think I'm worse off if tradable peak credits are introduced. b	Ardiç, 2015
Expected personal outcome (2)	I think that tradable peak credits give me financial benefits. b	Ardiç, 2015
Expected effort (1)	I think that trading peak credits will take a lot of effort. b	
Expected effort (2)	I think that trading peak credits will take a lot of time. b	
Expected enjoyment	I think trading peak credits will be fun. b	
Trust (1)	I think that a system with tradable peak credits is technically feasible. b	
Trust (2)	The government is able to implement and maintain a system with tradable peak credits. b	
Support (1)	To what extent are you in favor of the introduction of tradable peak credits system? d	
Support (2)	It is good to introduce a system with tradable peak credits. b	
Support (3)	To what extent are you in favor of the introduction of tradable peak credits system? d	
Problem perception congestion (1)	I personally suffer from traffic jams. b	
Problem perception congestion (2)	Traffic jams are a major problem for the the economy. b	
Problem perception environment	Traffic jams are a major problem for the environment. b	
Perceived behavioral control	It is easy to take alternatives (such as bicycle, public transport or other departure times) for most rush-hour car journeys. b	
a 1 = very unfair; 5 = very fair b 1 = fully disagree; 5 = fully agree c 1 = very ineffective; 5 = very effective d 1 = completely against; 5 = completely in favor		

5.5.2 Measuring preference for TPC over congestion charge and kilometer charge

We want to know to what extent people prefer TPC over a congestion charge and over a kilometer charge because these are alternative ways to reduce congestion. One possibility to

measure this is by adding a question to each choice set in the stated choice experiment: do you prefer the introduction of the TPC system of your choice, a congestion charge or a kilometer charge? However, it is expected that for most people this choice will not depend on the specific design of the TPC system. In that case it is unnecessary and even annoying to ask respondents this question six times. It was therefore decided to measure this preference in the questionnaire.

For each of the three measures, TPC, congestion charge and kilometer charge, the following question is asked: to what extent are you in favor of implementing this measure? Respondents can answer on a scale of 1 (completely against) to 5 (completely in favor). It was decided to work with a scale, instead of with binary answer option (for or against), because this gives more insight into the preferences of respondents. By using a scale, it is possible to observe that a respondent is in favor of several measures, but prefers one measure to the others. This scale also makes it possible to see the difference between the degree of conviction of respondents: one person may be strongly convinced of a measure and chooses answer 5, while the other is also in favor but less convinced of his choice and chooses answer 3.

5.6 Population and sample

The population of this study is people of 18 years and older who live in the transport regions of Amsterdam or Utrecht. It was chosen not to limit the population to people who own a driving license or a car. This research focuses on the public's preferences with regard to TPC and not only on the preferences of future users of that system. If the government evaluates whether a system like TPC will be introduced, the opinion of the public will play a role, not just the opinion of the drivers. Furthermore, the population was limited to the people living in and closely around the area in which the hypothetical TPC would be implemented. We are interested in the preferences of people who live in or closely near the area where the system would be implemented. This gives policy makers insight into how much support there is for such a measure in a certain area. It was chosen to focus on the transport regions Amsterdam and Utrecht, since these are regions where congestion is a problem. Moreover, it is considered plausible that if TPC is introduced, it will occur in an area of that size.

The goal was to have a representative sample of this population complete the survey. The company CG Research has recruited the respondents. In consultation with them, it was decided to focus on Utrecht in addition to Amsterdam, since they could not recruit enough respondents from Amsterdam alone. That is why there is also a version of the survey where not the municipality of Amsterdam, but the municipality of Utrecht is the location where TPC would be introduced. As a reward, respondents could earn points that they could exchange for a gift voucher from the online store Bol.com. They could earn 30 points, which is worth €1,50. In total, 513 respondents filled in the entire survey. Section 6.2 will discuss the sample characteristics.

5.7 Ethical considerations

Before the survey was conducted, permission was first requested for the research from the Human Research Ethics committee of TU Delft and permission was granted. Furthermore, the General Data Protection Regulation (GDPR) has been applicable since May 2018. For this research it is not necessary to be able to link answers to specific persons. In line with the principle of minimum data processing from the GDPR, the survey does therefore not request data from respondents that can be traced to a person. Respondents remain anonymous. In

addition, the respondents were informed that when they clicked through the survey their data would be saved and used for scientific research and publications. Furthermore, it was also emphasized in the introduction to the survey that the municipalities of Amsterdam and Utrecht currently not have plans to implement TPC, but that this was a hypothetical scenario for the purpose of this research. This was done to prevent people from having wrong expectations after participating in the survey.

5.8 Pilot survey

A pilot survey was conducted with the aim to improve the survey based on feedback. Snowballing was applied to collect respondents. A number of people were emailed with the request to participate in this pilot survey and to forward the request to people in their network. To test the pilot survey among an as varied audience as possible, they were asked to send the survey to people with certain characteristics in terms of age and education level. The expectation is that age and education level in particular influence how well people understand the survey. Ultimately, there was a reasonably varied target group in terms of age and education level.

People were asked to go through the survey, comment on whether all information was clear to them and provide points of improvement. They were also provided with two different ways of presenting the choice task and were asked which they prefered. Adjustments made to the survey based on feedback are explained in Appendix G.

6

Results - Public support for the introduction of TPC

This chapter presents the results associated with RQ 1, that studies the support for the introduction of TPC. For RQ 1.1, 1.2 and 1.4 it was necessary to model the choice of people for or against the introduction of TPC by means of discrete choice models and to interpret these models. This provides insight into the support that exists for the introduction of TPC, and how different groups of variables influence the choice of people to vote for or against the introduction of TPC. First, the data with which the choice models are estimated is prepared in Section 6.1. Then Section 6.2 provides more background by discussing the collected data. In Section 6.3, the choice models that model the choice between TPC and maintaining current situation are estimated and interpreted. Section 6.4 provides insight in the support levels for TPC, a congestion charge and a kilometer charge to answer RQ 1.5. For readers who only want to read the conclusions of the analyses, the main results are summarized in Section 6.5.

6.1 Preparation of data

The data is gathered between the 10th and 23rd of May 2019. 889 respondents opened the survey. 513 respondents completed the survey, 370 living in the transport region Amsterdam and 143 in the transport region Utrecht. This means the drop out range of the survey was 42.3%, which is quite high. Section 7.2 will discuss possible reasons for this high rate. The data set was cleaned to prepare it for the data analysis and the steps taken are described in Appendix J. After this, the data of 505 respondents was suitable to use. Since they each completed six choice tasks consisting of two questions, there were 6060 choice observations: 3030 choices between between two TPC systems and 3030 choices between introducing the preferred TPC system or not introducing it. As discussed in Section 5.4.2, blocking was used to divide the 12 choice sets in two blocks, and each respondent received one block of 6 choice sets. 52% of the respondents completed the choice sets of block 1, while 48% completed those of block 2, which is a good distribution for estimating the choice models.

The data preparation will be further discussed by showing how the variables were coded (Section 6.1.1) and how summated scales were constructed (Section 6.1.2).

6.1.1 Coding of variables

To estimate choice models, variables had to be coded first. Table 6.1 gives an overview of how the variables were coded. The attributes of the choice alternatives are all nominal variables and therefore all had to be coded. Since there is no clear base level for these attributes, effects coding was applied (Molin, 2011). Due to this, the average utility contribution of a variable is set to zero. The utility contribution of a level of a variable expresses the difference from the average utility contribution of that variable.

Level of education and income are considered interval variables. This is not entirely correct, since it is not certain that the distances between the categories are the same. If two people indicates to earn more than 100.000 euros, the distance between their income and the income of a person in the category 90.000 - 100.000 is not necessarily the same. However, the alternative is to estimate a set of dummy variables. Then many extra variables have to be estimated, which can decrease the statistical power. When the statistical power decreases, the probability of making a type II error, wrongly assuming that a coefficient is not significant, increases. So to prevent such a decrease in statistical power and for parsimony considerations it was chosen to consider the level of education and income as interval variables.

The table also shows how response categories from the survey are combined into new variables; for example the variable 'Car as main transport' based on the answers on the main transportation mode of respondents.

Table 6.1: Coding of variables

Variable	**Level**	**Coding**		
Attributes of the choice alternatives				
Recipients	All residents of the municipality.	1	0	0
	All residents of the municipality who own a car.	0	1	0
	All residents of the municipality + people who work there.	0	0	1
	All residents of the municipality + people who work there and own a car.	-1	-1	-1
Distribution principle	Credits are equally distributed among all recipients.	1	0	0
	People who have traveled more km will receive more credits.	0	1	0
	People who work more hours per week receive more credits than people who work less hours per week.	0	0	1
	People with a lower income receive more credits than people with a higher income.	-1	-1	-1
Credit allocation interval	Weekly	1		
	Monthly	-1		
Credit price fluctuation	Every minute	1		
	Every day	-1		
Introduction versions (context variables)				
Information type introduction	Explanation TPC	1		
	Explanation TPC & problem	-1		
Medium introduction	Video	1		
	Text	-1		

Socio-demographic variables				
Gender	Man	1		
	Woman	-1		
Income	Minder dan 10.000 euro	0		
	10.000 - 20.000 euro	1		
	20.000 - 30.000 euro	2		
	30.000 - 40.000 euro	3		
	40.000 - 50.000 euro	4		
	50.000 - 60.000 euro	5		
	60.000 - 70.000 euro	6		
	70.000 - 80.000 euro	7		
	80.000 - 90.000 euro	8		
	90.000 - 100.000 euro	9		
	100.000 euro of meer	10		
Education	Basisschool of geen diploma	0		
	Vmbo-kader / vmbo-basis / mbo 1	1		
	Vmbo gemengd / vmbo-t / havo (onderbouw) / vwo (onderbouw)	2		
	Mbo 2 / mbo 3 / mbo 4	3		
	Havo (bovenbouw) / vwo (bovenbouw)	4		
	Hbo-bachelor / wo-bachelor	5		
	Hbo-master / wo-master / doctor (PhD)	6		
Working situation	Student -I am a student / in training	1	0	0
	Retired -I am retired	0	1	0
	Other	0	0	1
	Paid job -I have paid work (up to 20 hours a week) -I have paid work (20 to 35 hours a week) -I have paid work (35 hours a week or more)	-1	-1	-1
Having children living at home	Yes -Single with children living at home -Living together / married with children living at home	1		
	No -Single without children living at home -Single with roommates -Living together / married without children living at home	-1		
Mobility habits				
License	No	-1		
	Yes	1		

Car as main transport	No -Train -Tram/subway -Bus -Motor -Moped/scooter -Bicycle/electric bicycle -Walking	-1
	Yes -Car (as driver) -Car (as passenger)	1
Commute travel expenses that are not reimbursed	No -I have no commuting costs -Fully reimbursed	-1
	Yes -Partially reimbursed -Not reimbursed	1

6.1.2 Constructing summated scales

In the estimated choice models, attitudes regarding TPC and car use will be included as explanatory variables. As discussed in Section 5.5.1 for part of the attitudes, multiple statements were constructed with the aim to combine them into one summated scale to represent the underlying attitude. Before constructing these summated scales, two conditions were tested: reliability of the scales and unidimensionality.

Unidimensionality
A condition for constructing a summated scale is that the statements are unidimensional. This means that 'they are strongly associated with each other and represent a single concept' (Hair et al., 2013, p. 123). A common way to test this is performing a factor analysis (Ziegler & Hagemann, 2015). A factor analysis was performed and the steps that were taken are discussed in Appendix K. The rotated factor-loading matrix that resulted from the factor analysis is presented in Figure 6.1. The structures for all assumed factors have been found as expected: all statements linked to an attitude load together on one factor. So, almost a perfect simple solution is reached. Only the statement *Perceived complexity (2)* loads on two factors: on one factor with statement *Perceived complexity (1)* as expected, but also on the factor together with the two statements related to *Expected effor*t. This could be expected since there are quite high correlations between these statements (0.538 and 0.606). Ideally there should be no cross-loadings, and it can be decided to omit statements with cross-loadings. However, since *Perceived complexity (2)* also has a high loading on a separate factor together with *Perceived complexity (1)* it was chosen not to omit this statement and to accept the fact that this statement also has a high loading on another factor.

Reliability
It was investigated whether the internal consistency of the scales is high enough. Reliability of the scale is a measure for this internal consistency. There is discussion about the correct way to measure the reliability of scales with a two-item constructs. This is relevant, since almost all scales in this study consist of only two statements (constructs). Based on the discussion by Eisinga et al. (2013), it was chosen to report both the Cronbach's Alpha and the Spearman-

Brown of each scale. Table 6.2 presents these values for all the summated scales that were tested.

Based on the Cronbach's Alpha and Spearman-Brown values, the following scale variables were reliable enough: *Perceived effectiveness congestion sum, Expected effort sum, Trust sum* and *Perceived fairness sum.* Two scales were clearly not reliable enough and were therefore not constructed: expected personal outcome and problem perception. One scale, perceived complexity sum, was questionable since it has a Cronbach's Alpha value of 0.688. Often values higher than 0.7 are considered good enough (Santos, 1999), but the opinions differ about values between 0.6 and 0.7. In this research it was chosen to construct the summated scale based on the Cronbach's Alpha value of 0.688.

Constructing the summated scales

Expected personal outcome and *Problem perception* did not meet the conditions regarding reliability and unidimensionality for constructing a summated scale. The single statements linked to these attitudes were all used as separate variables in estimating the choice models, instead of combined as summated scales. For the other attitudes summated scales were constructed and scores for these scales were calculated by adding up the score on the variables that are part of the scale and dividing this score by 2. In this way, the scale variables are measured in on a scale of 1 to 5, just like the other attitudinal variables.

	Factor				
	1	2	3	4	5
Perceived effectiveness congestion (1)				,945	
Perceived effectiveness congestion (2)				,846	
Perceived complexity (1)					,637
Perceived complexity (2)		,578			-,387
Expected effort (2)		,747			
Expected effort (1)		,859			
Trust (1)			,805		
Trust (2)			,785		
Perceived fairness (1)	,887				
Perceived fairness (2)	,806				

Figure 6.1: Rotated factor-loading matrix with Direct Oblimin rotation

Table 6.2: Reliability analysis for the summated scales

Scale variable	**Statements**	**Cronbach's Alpha**	**Spearman -Brown**
Perceived effectiveness congestion sum	Perceived effectiveness congestion (1) - "I think tradable peak credits reduce traffic jams." [b]	0.903	0.903
	Perceived effectiveness congestion (2) - "How effective do you think peak credits reduce traffic jams?" [c]		

Perceived complexity sum	Perceived complexity (1) (mirrored) - "I find tradable peak credits easy to understand." [b]	0.668	0.668
	Perceived complexity (2) - "I find peak credits very complicated." [b]		
	Expected personal outcome (1) (mirrored) - "I think I'm worse off if tradable peak credits are introduced." [b]	0.451	0.453
	Expected personal outcome (2) - "I think that tradable peak credits give me financial benefits." [b]		
Expected effort sum	Expected effort (1) - "I think that trading peak credits will take a lot of effort." [b]	0.8	0.801
	Expected effort (2) - "I think that trading peak credits will take a lot of time." [b]		
Trust sum	Trust (1) - "I think that a system with tradable peak credits is technically feasible." [b]	0.783	0.783
	Trust (2) - "The government is able to implement and maintain a system with tradable peak credits." [b]		
Perceived fairness sum	Perceived fairness (1) - "How honest do you find tradable peak credits for yourself?" [a]	0.865	0.865
	Perceived fairness (2) - "How honest do you find tradable peak credits for others?" [a]		
	Problem perception congestion (1) - "I personally suffer from traffic jams." [b]	0.2	0.202
	Problem perception congestion (2) - "Traffic jams are a major problem for the the economy." [b]		
[a] 1 = very unfair; 5 = very fair [b] 1 = fully disagree; 5 = fully agree [c] 1 = very ineffective; 5 = very effective [d] 1 = completely against; 5 = completely in favor			

6.2 Descriptive results

First it will be checked whether the sample is representative for the population in background characteristics (Section 6.2.1). The implications of unrepresentativeness will also be discussed. Subsequently, more insight into the sample is given by discussing sample characteristics (Section 6.2.2). To supplement this, a picture is drawn of how the sample views different aspects

of TPC (Section 6.2.3). Finally, Section 6.2.4 describes the choices made by respondents in the stated choice experiment.

6.2.1 Representativeness of the sample and implications of this

Statistical test were performed to test whether the obtained sample is representative for the population in terms of gender, age, educational level and income. The tests and their results are documented in Appendix L. Table 6.3 also presents the characteristics in the sample and in the population. The population is people living in the transport regions Amsterdam and Utrecht. However since the required data could not be found about this region, number on the municipalities of Amsterdam and Utrecht were used as a proxy of the population numbers.

The sample turns out to be unrepresentative for the population in terms of gender, age and educational level. It could not be determined whether it is representative in terms of income, due to the high amount of missing values. Females are overrepresented, while male are underrepresented. People aged under 45 are underrepresented in the sample, as are people older than 80. People aged 65 to 80 are highly overrepresented. Regarding educational level, the low and high educational levels are underrepresented and the middle educational levels are overrepresented.

But what are the implications of the unrepresentativeness of the sample for the population in terms of gender, age and educational level for this study? This will be discussed separately for the choice model estimations that answer RQ 1.1, 1.2 and 1.4 and for the support values for TPC, congestion charge and kilometer charge that answer RQ 1.5.

Implications for the choice model estimations
The collected data will be used to estimate logit choice models that are based on correlations. Since correlations are not really sensitive to representativeness of variable distributions, the unrepresentativeness of the sample does not necessarily pose problems. Correlations in the sample can still be good predictors for the population. However, this is only the case if two conditions are met: 1) each category of the variable is sufficiently represented, 2) the dropout in the category of a variable that is underrepresented must be random. If this dropout is not random, then the people belonging to the underrepresented category that completed the survey might behave different compared to the the people in this category who did not complete the survey. Regarding the first condition: this condition is met since all categories have at least 30 observations, which can be considered enough. Whether the second condition is met is uncertain. Since recruitment was conducted among panel members, members were able to choose for themselves whether they wanted to take part in the survey. This can lead to people with certain characteristics completing the survey more often. It might be the case that people with a stronger interest in the subject, or a stronger opinion about TPC (positive or negative) take part in the survey more. There was also a high dropout rate in the survey; here too it may be that people who find the subject less interesting, understand it less good or have a less strong opinion about it, drop out more often. If this is the case, the dropout is not random. However, the dropout is then not random in all categories of a variable, and not only in the underrepresented category. If the dropout within the entire variable is non-random in the same way, then correlations can still be estimated, but the opinions in the sample may be more extreme than in the entire population.

Implications for the support values
The unrepresentativeness of the sample might thus not have implications for the choice models since they rely on correlations. However, it may have implications for other measures in this study. To answer RQ 1.5 ‘To what extent is the introduction of a TPC system preferred to

the introduction of other road pricing policies, specifically a congestion charge and a kilometer charge?' respondents were asked to indicate their support for TPC, congestion charge and kilometer charge on a scale of 1 to 5. The mean values of indicated support will be compared to answer RQ 1.5. However, if certain characteristics of the sample influence the support for these three measures, and the sample deviates from the population in terms of these characteristics, then the results based on the sample may not be a good predictor for results in the population. An example to illustrate this: if older people support TPC less, and if older people are overrepresented in the sample, then the mean support for TPC in the sample will underestimate the support for TPC in the population. It is therefore important to test if characteristics correlate with the support for TPC, congestion charge and kilometer charge. This will be done in Section 6.4 where RQ 1.5 will be answered. Section 6.2.2 discusses in what characteristics the sample deviates from the population and in which way these characteristics might affect the support for TPC.

6.2.2 Sample characteristics

The sample characteristics are given in Table 6.3 and 6.4. The distributions in the population are also presented in this table if they were available to show deviations between the sample and the population. The population numbers were retrieved from CBS Statline. There were no numbers on main mode of transport available of the population (the municipality of Utrecht and Amsterdam), so numbers of the entire Netherlands are used as a proxy of the population statistics. The source of these numbers is the 'Onderzoek Verplaatsingen in Nederland' (OViN) 2016 of the CBS. The most important deviations between the sample and the population will be discussed in this section.

In particular, the deviations between the sample and the population in terms of age appear to have implications for other characteristics in the sample. Only 24% of the sample has children living at home. This is relatively low number is to be expected, considering the fact that people aged under 45 are underrepresented in the sample. The amount of retired people is quite high with 25% which can be explained by the fact that people aged 65 to 80 are overrepresented in the sample. This is expected to have implications for opinions regarding TPC in the sample. On the other hand, it is to be expected that relatively old people may be less positive about a system where they have to trade rights digitally. Older people are more often unsure about the use of technology and find it harder to get used to new systems.

As TPC is a traffic measure, it is also interesting to get a picture of the mobility habits of the respondents. The amount of respondents for who a car is their main mode of transport is almost the same as for people in the Netherlands (44% compared to 47% in the Netherlands). The fact that this percentage is slightly lower in the sample is probably because the sample was taken in an urban area. People in urban areas live closer to facilities and perhaps also to work, which means that shorter distances have to be covered. This means that other means of transport than the car can be taken more often. Public transport as main mode of transport occurs far more often in the sample (17%) than in the Netherlands (5%). This can also be due to the fact that all respondents live in urban areas, where public transport such as buses and trams are likely to be used more often. Furthermore the people for who walking is their main mode of transport are underrepresented.

57% of the sample indicates that on average their weekly amount of trips during peak hours is zero. This is probably due to the fact that the sample is from an urban area. For 73% of the sample it is two trips or less. 6% of the sample makes 10 trips during peak hours on average every week. The average weekly amount of trips during peak hours is 2.05 in the sample. This is almost exactly the same as the average in the Netherlands in 2011, which was 2.04.

Since car use has increased in the last years, this number has probably also increased. So the sample probably makes slightly fewer trips during peak hours per week than the average of the Dutch population, but the difference is probably not large. The sample therefore gives a good reflection of the number of car users and the number of journeys they make during peak hours.

Of the people that weekly drive during peak hours, on average 68% of those trips they experience congestion. 40% of these people even experiences congestion during every trip during peak hours. The average amount of trips with car during peak hours during which congestion is experienced per week is 1.42. So only a small percentage of the sample often drives during rush hour, and the ones that do experience congestion during most of these trips.

Table 6.3: Sample characteristics part one

Characteristic			**Percentage sample**	**Percentage population**
Socio-demographic variables				
Gender	Male		42.3	49.4
	Female		57.7	50.6
Age	18-25		6.1	13.7
	25-45		31.3	45.2
	45-65		30.9	29.3
	65-80		29.9	11.6
	80+		1.8	3.3
Educational level	Low	Basisschool of geen diploma	0,6	16.2
		Vmbo-kader Vmbo-basis Mbo 1	6.1	
		Vmbo gemengd Vmbo-t Havo (onderbouw) Vwo (onderbouw)	5.9	
	Medium	Mbo 2 / 3 / 4	17.2	27.1
		Havo (bovenbouw) Vwo (bovenbouw)	16.2	
	High	Hbo-bachelor Wo-bachelor	32.1	56.6
		Hbo-master Wo-master Doctor (PhD)	21.8	
Income	Less than 10.000 euros		4.6	-
	10.000 - 20.000 euros		10.5	-
	20.000 - 30.000 euros		15.4	-
	30.000 - 40.000 euros		15.8	-
	40.000 - 50.000 euros		11.5	-
	50.000 - 60.000 euros		7.7	-
	60.000 - 70.000 euros		3.8	-
	70.000 - 80.000 euros		3.4	-
	80.000 - 90.000 euros		2.2	-
	90.000 - 100.000 euros		1.4	-
	100.000 euros or more		2.8	-

	I would rather not say	21	-
Living situation	Single with roommates	2	-
	Single without children living at home	39	-
	Single with children living at home	5	-
	Living together/married without children living at home	33	-
	Living together/married with children living at home	19	-
	Living with parents	2	-
Work situation	Student/ in training	5	11.1
	Retired	25	13.4
	Paid work (up to 20 hours per week)	11	-
	Paid work (20 to 35 hours per week)	18	-
	Paid work (35 hours per week or more)	25	-
	Other (e.g. incapacitated, volunteering)	14	-
Mobility habits			
Main means of transport	Car (as driver)	41	33
	Car (as passenger)	3	14
	Motor	1	Unknown
	Train	7	2
	Tram/subway	7	3
	Bus	3	
	Moped/scooter	2	1
	Bicycle/electric bicycle	29	27
	Walking	5	18

Table 6.4: Sample characteristics part two

Mobility habits	**Sample**		**Population**
	Mean	**Standard deviation**	**Mean**
Amount of trips with car during peak hours per week per person	2.05	3.147	2.04*
Amount of trips with car during peak hours during which congestion is experienced per week	1.42	2.563	Unknown
* According to CBS (2012), in 2011 on a weekday the amount of cars on the road during peak hours was 2.4 million in the morning, and 2.8 million in the evening on average. This is used as a proxy for the average amount of trips during peak hours on a weekday. According to CBS Statline, in 2011 there were 12.741.980 people aged 20 years and older. So, 5.2 million trips during peak hours were made by 12.741.980 people. This means that the average amount of peak trips per person per day is 0.41. The average weekly amount of trips during peak hours per person is then 2.04.			

6.2.3 Attitudes relevant for TPC

In the survey, statements were presented to the respondents to measure several attitudes with regard to TPC and car use (see Section 5.5.1). This section discusses the most important insights gained from this. In this way a picture is drawn of how respondents view different aspects of TPC. Table 6.5 presents the means and standard deviations of the measured attitudinal variables. All these variables are measured on a scale of 1 to 5. In the discussion that follows, answers 4 and 5 are considered as agreeing with the statement, and answers 1 and 2 as disagreeing with the statement.

There is a clear consensus that congestion is a problem for the economy (64%) and for the environment (77%). Only 18% of the respondents however indicates to personally suffer from traffic jams, while 58% indicates not to suffer from it. Congestion is thus widely seen as a problem, but not so much personally experienced by respondents as a problem. This might relate to the fact that only a small percentage of the sample often drives during rush hour as discussed in Section 6.2.2.

There is no great conviction among respondents that TPC will reduce congestion. Only 33% of the respondents believes this, while 41% thinks that TPC will not reduce congestion. Also when asking whether TPC will reduce the impact of car use on the environment, the amount of respondents who do not think this (40%) is greater than the amount of respondents who do (31%).

The sample is heterogeneous regarding the outcome that they expect for themselves if TPC were introduced. 36% think that they will be worse off, 35% think they will be better off and 29% think they are neither worse, nor better off. Financial benefits are only expected to a limited extent; 20% expects them, while 49% does not.

When asking whether respondents think that tradable peak credits are fair for themselves and for others, most respondents find it neither fair nor unfair (respectively 49% and 43%). The other respondents who find it either fair or not fair and are fairly evenly distributed among these groups.

The majority of respondents, 51%, considers TPC an infringement on personal (mobility) freedom. Respondents are more divided about whether TPC is a violation of privacy. The biggest group, 39% of the respondents thinks so. However, only a slightly smaller group, 34% of respondents, does not think this is the case.

The sample is also very heterogeneous in whether they find TPC complicated. 36% finds it complicated, 33% finds it easy and the remaining 31% is in between.

In general, it is expected by respondents that TPC will take a lot of effort and give little pleasure. Many respondents think that trading in peak credits will take a lot of time (48%) and effort (49%) compared to 23% who do not expect this. Only 23% of the respondents thinks that trading peak credits will be fun, compared to 53% who thinks it will not be fun.

Many respondents think that realizing a TPC system is technically feasible (48% compared to 23% who do not think so), but the number of respondents who also think that the government is capable of implementing and maintaining such a system is considerably lower (27% believe the government is capable, compared to 40% who do not).

Table 6.5: Decribtive statistics regarding the attitudinal variables

Attitudinal variable	Statement	How often answer is given in percentages					Mean	St. dev.
		1	2	3	4	5		
Perceived fairness sum	How honest do you find tradable peak credits for yourself? [a]	13	15	49	19	4	2.84	0.94
	How honest do you find tradable peak credits for others? [a]	12	22	43	20	4		
Perceived effectiveness congestion sum	I think tradable peak credits reduce traffic jams. [b]	23	18	26	23	10	2.71	1.16
	How effective do you think peak credits reduce traffic jams? [c]	23	17	36	21	3		
Perceived effectiveness environment	I think that tradable peak credits reduce the impact of car use on the environment. [b]	25	15	29	23	8	2.72	1.28
Perceived complexity sum	I find tradable peak credits easy to understand. [b]	13	14	26	31	16	2.92	1.07
	I find peak credits very complicated. [b]	13	20	31	22	14		
Perceived infringement on freedom	I view tradable peak credits as an infringement on the personal (mobility) freedom. [b]	10	14	25	24	27	3.44	1.29
Perceived infringement on privacy	I think tradable peak credits will violate the privacy of people. [b]	13	21	27	20	19	3.12	1.3
Expected personal outcome (1)	I think I'm worse off if tradable peak credits are introduced. [b]	19	16	29	16	20	3.01	1.37
Expected personal outcome (2)	I think that tradable peak credits give me financial benefits. [b]	31	18	30	14	6	2.45	1.23
Expected effort sum	I think that trading peak credits will take a lot of effort. [b]	7	16	28	29	20	3.4	1.06
	I think that trading peak credits will take a lot of time. [b]	5	18	30	28	20		
Expected enjoyment	I think trading peak credits will be fun. [b]	38	15	24	15	8	2.4	1.33
Trust sum	I think that a system with tradable peak credits is technically feasible. [b]	5	18	30	28	20	2.91	1.11
	The government is able to implement and maintain a system with tradable peak credits. [b]	25	15	33	19	8		
Support (1)	To what extent are you in favor of the introduction of a tradable peak credits system? [d]	29	14	31	17	9	2.63	1.31
Support sum	It is good to introduce a system with tradable peak credits. [b]	28	15	26	22	10	2.59	1.27
	To what extent are you in favor of the introduction of tradable peak credits system? [d]	35	16	23	20	7		
Problem perception congestion (1)	I personally suffer from traffic jams. [b]	30	28	24	11	7	2.38	1.21
Problem perception congestion (2)	Traffic jams are a major problem for the the economy. [b]	3	7	26	34	30	3.81	1.03
Problem perception environment	Traffic jams are a major problem for the environment. [b]	3	3	17	34	43	4.1	1
Perceived behavioral control	It is easy to take alternatives (such as bicycle, public transport or other departure times) for most rush-hour car journeys. [b]	13	17	27	21	22	3.22	1.31

[a] 1 = very unfair; 5 = very fair
[b] 1 = fully disagree; 5 = fully agree
[c] 1 = very ineffective; 5 = very effective
[d] 1 = completely against; 5 = completely in favor

6.2.4 Choice behavior of respondents

For each choice set, respondents were first asked to indicate their preference between two presented TPC systems. Figure 6.2 shows the distribution of choices made by respondents. This shows that there were no choice sets with a clearly dominant alternative.

Next, respondents were asked whether they would vote for the introduction of the TPC system they chose in question one, or against the introduction of a TPC system. Figure 6.3 shows how respondents answered this question. When respondents voted for the introduction of TPC, the TPC system they chose in question 1 was considered as their answer to question 2. When respondents voted against the introduction of TPC, 'no TPC system' was considered their answer. The percentage of respondents that voted against the introduction of TPC lies between 41% and 55% considering all choice sets.

In total, respondents voted for the introduction of the TPC system of their preference 1536 times, while 1494 times they voted against it. So, 51% of the votes were in favor of the introduction of TPC.

60.1% of the respondents voted the same in each of the six choice sets that were presented

to them. 52.6% of them always voted against the introduction of TPC, and the other 47.7% always voted in favor of introducing TPC. The votes of the remaining 39.9% differed per choice set. So, it seems that for a large part of the respondents is in favor or against the introduction of TPC, independent of the specific design of the TPC system. Within this group, the number of respondents in favor of TPC and the number of respondents against TPC is very close to each other. The sample is therefore very heterogeneous in their support for TPC.

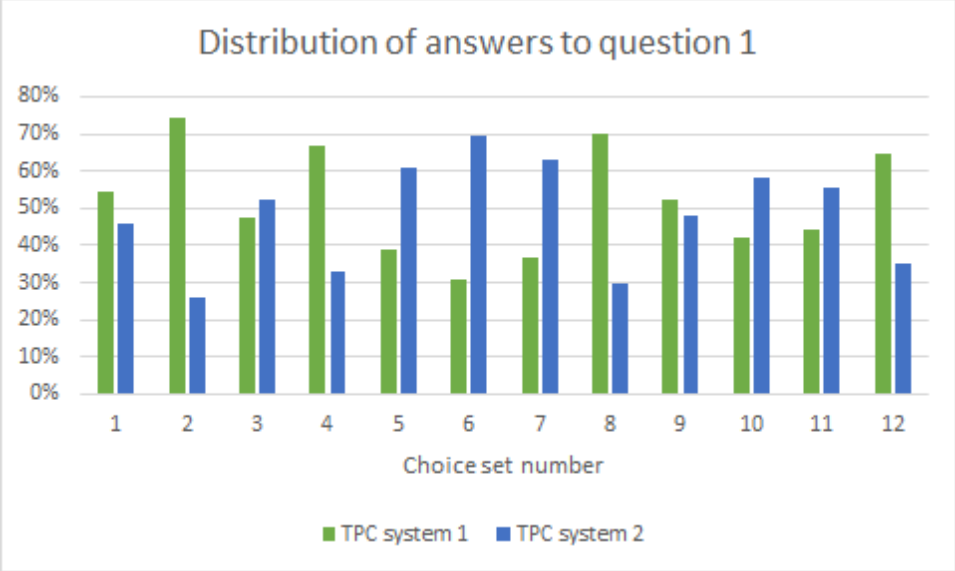


Figure 6.2: The distribution of answers given to the first question of every choice set

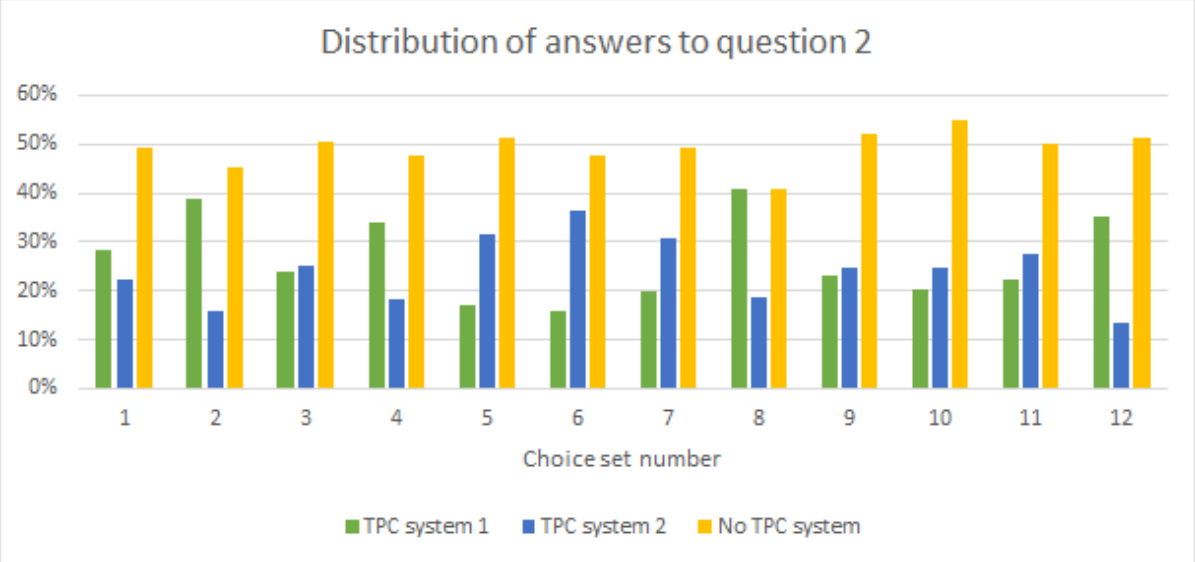


Figure 6.3: The distribution of answers given to the second question of every choice set

6.3 Modelling the choice between TPC designs and maintaining the current situation

First the estimated models are presented in Section 6.3.1. Then the models are compared in Section 6.3.2 to decide which model will be further used. The interpretation of that models

follows in the subsequent sections. The model fit is first discussed in Section 6.3.3. Then, for each group of variables, it is discussed how they influence the choice of respondents for or against TPC input in Section 6.3.4, 6.3.5 and 7.4. The influence of the introduction versions will not be discussed here, but in Chapter 7 since this relates to RQ 2.

6.3.1 Estimated choice models

The choice models were estimated using PandasBiogeme (Bierlaire, 2018).

MNL model
First of all a MNL model with three alternatives, two TPC systems and one opt-out alternative, was estimated. The final MNL model is constructed by iteratively expanding the deterministic component of the utility function. The basic model is a model with the variables that are varied in the choice experiment: the attributes of the alternatives and variables relating to the introduction version. These variables remain included in the model, even if they appear not to be significant. Next it is examined whether the model fit can be increased by adding more variables that were measured in the questionnaire to the model, namely the characteristics of the respondent. The characteristics that were measured are socio-demographic characteristics, mobility habits and attitudes regarding TPC and car use. It is explored whether these variables can improve the model fit without substantiated hypothesis. Therefore, variables that turn out not to be significant will be excluded from the model. The steps that were taken in estimating the MNL model will now be explained. The estimation results of the final MNL model are presented in Table 6.6.

Attributes of the alternatives
First a model was estimated with only the attributes of the alternatives:

- The recipients of free credits
- The distribution principle
- The credit allocation interval
- The credit price fluctuation

Also, an alternative-specific constant was added to the utility function of the TPC alternatives. The adjusted ρ^2 of this model was 0.063.

Choice context variables
The choice context was varied in the experiment in two ways: the type of information included in the introduction of TPC and the medium through which the information was presented to respondents (for more information, see Section 5.3.4). One variable was created to indicate which information type respondents received, 'Explanation TPC' or 'Explanation TPC & problem', and one variable was created to indicate whether respondents received the information via text or via a video. The model was extended with these variables. The adjusted ρ^2 of this model was 0.064. This increase in model fit was significant at the 99% significance level (LRS = 10.25, df = 2). The influence of the introduction versions will not be discussed in this chapter, but in Chapter 7 since this relates to RQ 2.

Socio-demographic variables
Next it was tested whether extending the model with socio-demographic variables could improve the model fit. Next to main effects, also a few interaction effects that seemed plausible to exist were included. The effects of the following variables were studied:

- Gender
- Age

  - Interaction between age and credit price fluctuation
- Level of education
- Income
  - Interaction between income and distribution principle level 'People with a lower income receive more credits than people with a higher income'.
- Possession of a license
- Work situation (student, retired, paid job or other situations)
  - Interaction between work situation level 'paid job' and distribution principle level 'People who have traveled more km will receive more credits'.
  - Interaction between work situation level 'paid job' and distribution principle level 'People who work more hours per week receive more credits than people who work less hours per week'.
- Having children living at home
  - Interaction between having children living at home and distribution principle level 'People who have traveled more km will receive more credits'.

After having removed the variables that turned out to be insignificant, the ρ^2 of this model was 0.066. When comparing this model fit to the model fit of the model including only attributes and choice context variables, the increase in model fit was significant at the 99% significance level (LRS = 19.284, df = 4).

Mobility habits

Next it was tested whether extending the model with variables reflecting the mobility habits of respondents could improve the model fit. Next to main effects, also a few interaction effects that seemed plausible to exist were included. The effects of the following variables were studied:

- Car as main mode of transport
- Weekly number of trips during rush hour
  - Interaction between weekly number of trips during rush hour and distribution principle level 'People who have traveled more km will receive more credits'.
- Weekly number of trips during rush hour where there is slow-moving or stationary traffic
  - Interaction between weekly number of trips during rush hour and distribution principle level 'People who have traveled more km will receive more credits'.
- The existence of commute travel expenses that are not reimbursed

After having removed the variables that turned out to be insignificant, the ρ^2 of this model was 0.069. When comparing this model fit to the model fit of the model including attributes, choice context variables and socio-demographic variables, this increase in model fit was significant at the 99% significance level (LRS = 30.554, df = 3).

Attitudes regarding TPC and car use

Lastly, attitudes of respondents regarding TPC and car use were added to the model to see whether this could improve the model fit. Table 5.2 in Section 5.5.1 indicates which statements were used to measure these attitudes among respondents. The following variables were added to the model:

- Perceived fairness
- Perceived effectiveness congestion

- Perceived effectiveness environment
- Perceived complexity
- Perceived infringement on freedom
- Perceived infringement on privacy
- Expected personal outcome
- Expected effort
- Expected enjoyment
- Trust in feasibility
- Problem perception congestion
- Problem perception environment
- Perceived behavioral control

After having removed the variables that turned out to be insignificant, the ρ^2 of this model was 0.192. When comparing this model fit to the model fit of the model including attributes, choice context variables, socio-demographic variables and mobility habits, this increase in model fit was significant at the 99% significance level (LRS = 830.4, df = 6). The utility functions of the final MNL model are presented in equation 6.1 and 6.2.

$$\begin{aligned} U_{TPC} = {} & ASC_{TPC} + \beta_{interval} \cdot Interval + \beta_{recipients1} \cdot Recipients1 + \beta_{recipients2} \cdot Recipients2 \\ & + \beta_{recipients3} \cdot Recipients3 + \beta_{distribution1} \cdot Distribution1 + \beta_{distribution2} \cdot Distribution2 \\ & + \beta_{distribution3} \cdot Distribution3 + \beta_{fluctuation} \cdot Fluctuation + \beta_{informationtype} \cdot Information \\ & type + \beta_{medium} \cdot Medium + \beta_{education} \cdot Education + \beta_{student} \cdot Student + \beta_{retired} \cdot Retired \\ & + \beta_{otherworksituations} \cdot Otherworksituations + \beta_{weeklytrips} \cdot Weeklytrips + \beta_{travelexpenses} \\ & \cdot Travelexpenses + \beta_{enjoyment} \cdot Enjoyment + \beta_{personaloutcome} \cdot Personaloutcome \\ & + \beta_{effectivenesscongestion} \cdot Effectivenesscongestion + \beta_{effectivenessenvironment} \cdot \\ & Effectivenessenvironment + \beta_{fairness} \cdot Fairness + \beta_{infringementfreedom} \cdot Infringement \\ & freedom + \beta_{trust} \cdot Trust + \epsilon_{TPC} \end{aligned} \tag{6.1}$$

$$U_{NoTPC} = \epsilon_{NoTPC} \tag{6.2}$$

ML panel model

Also a panel Mixed Logit model was estimated. This was approached in the same iterative way as described for the MNL model. Monte-Carlo simulation was used with draws from a normal distribution. When estimating the models, the number of draws was always increased, until the results became stable and therefore hardly changed when increasing the number of draws. 700 draws were needed for each ML model to get stable results. The estimation results of the final ML model are presented in Table 6.6. This final model was estimated using 1000 draws. The steps that were taken in estimating the ML model will now be explained.

Basic model with nest of TPC alternatives

First a basic model was estimated with only the attributes of the alternatives, the choice context variables (the type of information included in the introduction and the medium) and

an alternative-specific constant was added to the utility function of the TPC alternatives. Furthermore, nesting effects are captured by adding an additional error component to the utility functions of the TPC alternatives that represents the utility of their common unobserved factors. The adjusted ρ^2 of this model was 0.0662.

Panel effects

The model was extended by capturing panel effects: the correlation between choices made by an individual over time. The adjusted ρ^2 of this model was 0.291.

Random taste heterogeneity

It was tested whether there is taste heterogeneity among respondents for the attributes of the alternatives: the recipients of free credits, the distribution principle, the credit allocation interval and the price fluctuation interval. After having removed the insignificant sigma's, the ρ^2 of this model was 0.302. When comparing this model fit to the model fit of the model including attributes, choice context variables, a nest of TPC alternatives and panel effects, this increase in model fit was significant at the 99% significance level (LRS = 85.156, df = 4).

Addition of variables

Finally, it was tested whether extending the model with socio-demographic variables, mobility habits and attitudes regarding TPC and car use could improve the model fit. The same variables and interaction effects as added to the MNL model were added. After having removed the variables that turned out to be insignificant, the ρ^2 of this model was 0.330. When comparing this model fit to the model fit of the model including attributes, choice context variables, a nest of TPC alternatives, panel effects and random taste heterogeneity, this increase in model fit was significant at the 99% significance level (LRS = 224.966, df = 5). The utility functions of the final panel ML model are presented in equation 6.3 and 6.4.

$$\begin{aligned} U_{n,TPC} = {} & ASC_{TPC} + \upsilon_{n,TPC} + \beta_{interval} \cdot Interval + \beta_{n,recipients1} \cdot Recipients1 + \beta_{recipients2} \cdot Recipients2 \\ & + \beta_{recipients3} \cdot Recipients3 + \beta_{n,distribution1} \cdot Distribution1 + \beta_{n,distribution2} \cdot Distribution2 \\ & + \beta_{n,distribution3} \cdot Distribution3 + \beta_{fluctuation} \cdot Fluctuation + \beta_{informationtype} \cdot Information \\ & type + \beta_{medium} \cdot Medium + \beta_{enjoyment} \cdot Enjoyment + \beta_{effectivenessenvironment} \cdot Effectiveness \\ & environment + \beta_{fairness} \cdot Fairness + \beta_{infringementfreedom} \cdot Infringementfreedom \\ & + \beta_{trust} \cdot Trust + \epsilon_{n,TPC} \end{aligned} \tag{6.3}$$

Where:

$$\upsilon_{n,TPC} \sim N(0, \sigma_{\upsilon_{TPC}})$$

$$\beta_{n,recipients1} \sim N(\beta_{recipients1}, \sigma_{\beta_{recipients1}})$$

$$\beta_{n,distribution1} \sim N(\beta_{distribution1}, \sigma_{\beta_{distribution1}})$$

$$\beta_{n,distribution2} \sim N(\beta_{distribution2}, \sigma_{\beta_{distribution2}})$$

$$\beta_{n,distribution3} \sim N(\beta_{distribution3}, \sigma_{\beta_{distribution3}})$$

$$U_{n,NoTPC} = \epsilon_{n,NoTPC} \tag{6.4}$$

For every respondent n, five values are drawn from normal distributions. The β's and σ's that define these distributions are estimated and reported in Table 6.6. Due to this, four β's

can vary across individuals which allow for taste heterogeneity as discussed earlier. Also the additional error component which captures nesting effects, $\upsilon_{n,TPC}$, can vary across individuals. Correlation between the unobserved utility of TPC alternatives is taken into account due to this. Furthermore, panel effects are taken into account in the ML model. This is not visible in the utility function, but in the way the log-likelihood function is estimated. When this is now estimated, the unit of observation is not one choice, but the sequence of choices made by one individual. Due to this, the draws from the normal distributions apply to all choices of one individual.

Table 6.6: Final model estimation results

Attribute	**MNL-model**			**ML-model**		
	Coëfficiënt	**Standard error**	**T-value (p-value)**	**Coëfficiënt**	**Standard error**	**T-value (p-value)**
ASC Tradable Peak Credits	-3.14	0.297	-10.55 (0.00)	-3.49	0.551	-6.33 (0.00)
Attributes of the alternatives						
Recipients						
-R1 (Residents municipality)	-0.280	0.0766	-3.65 (0.00)	-0.576	0.122	-4.74 (0.00)
-R2 (Residents municipality who own a car)	-0.0249*	0.0900	-0.28 (0.78)	0.0721*	0.13	0.553 (0.58)
-R3 (Residents municipality + people who work there)	-0.0302*	0.0673	-0.45 (0.65)	0.0609*	0.088	0.691 (0.489)
Distribution principle						
-D1 (Equal distribution)	0.313	0.0720	4.35 (0.00)	0.587	0.111	5.31 (0.00)
-D2 (More km traveled, more credits)	-0.00556*	0.0910	-0.06 (0.95)	-0.098*	0.132	-0.743 (0.457)
-D3 (More hours working, more credits	-0.165	0.0630	-2.62 (0.01)	-0.234	0.0955	-2.45 (0.0143)
Price fluctuation	-0.109	0.0428	-2.56 (0.01)	-0.186	0.062	-3.01 (0.00)
Allocation interval	-0.0856	0.0337	-2.56 (0.01)	-0.147	0.0424	-3.46 (0.00)
Choice context variables (introduction versions)						
Information type introduction	-0.0733*	0.0431	-1.70 (0.09)	-0.258*	0.183	-1.41 (0.159)
Medium introduction	0.0985	0.0434	2.27 (0.02)	0.245*	0.178	1.38 (0.168)
Socio-demographic variables						
Education	-0.158	0.0301	-5.23 (0.00)	-	-	-
Work situation: other situations	-0.0189*	0.0769	-0.25 (0.81)	-	-	-
Work situation: retired	0.347	0.0890	3.90 (0.00)	-	-	-
Work situation: student	-0.328	0.117	-2.80 (0.01)	-	-	-
Mobility habits						
Weekly amount of trips during peak hours	0.0450	0.0155	2.90 (0.00)	-	-	-
Commute travel expenses that are not reimbursed	0.241	0.0951	2.53 (0.01)	-	-	-
Attitudes regarding TPC and car use						
Expected enjoyment	0.201	0.0437	4.60 (0.00)	0.452	0.175	2.59 (0.01)
Expected personal outcome (2)	0.0930	0.0427	2.18 (0.03)	-	-	-
Perceived effectiveness congestion	0.151	0.0341	4.42 (0.00)	-	-	-

Perceived effectiveness environment	0.198	0.0566	3.50 (0.00)	0.86	0.189	4.56 (0.00)
Perceived fairness	0.144	0.0355	4.05 (0.00)	0.863	0.27	3.19 (0.00)
Perceived infringement on freedom	-0.159	0.0392	-4.05 (0.00)	-0.474	0.156	-3.03 (0.00)
Trust	0.0937	0.0244	3.84 (0.00)	0.563	0.196	2.87 (0.00)
Sigma's of parameters						
Sigma Tradable Peak Credits	-	-	-	-3.42	0.235	-14.6 (0.00)
Sigma D1 (Equal distribution)	-	-	-	0.682	0.121	5.64 (0.00)
Sigma D2 (More km traveled, more credits)	-	-	-	-0.669	0.112	-6.00 (0.00)
Sigma D3 (More hours working, more credits	-	-	-	-0.745	0.122	-6.11 (0.00)
Sigma R1 (Residents municipality)	-	-	-	0.656	0.127	5.18 (0.00)
Log-likelihood (LL)	-2.664.659			-2.195.522		
Adjusted ρ^2	0.192			0.330		
*Not significant at 95% significance level						

6.3.2 Comparing the MNL and ML model

The ML panel model has a much higher model fit than the MNL model. To test whether the difference in model fit is significant, the Ben-Akiva & Swait test was used, since the models are nonnested. This test showed that the chance that the MNL model is a better model in the population, although the ML model fits the sample data better, is smaller than 0.00%. So, the difference in model fit is highly significant. Therefore, the ML model will be interpreted in the remainder of this chapter and will be used to answer the research questions.

There are several coefficients that were significant in the MNL model, but not in the ML model. An explanation for this is that parameters can become significant while they are not when it is assumed that choices made by the same individual are not correlated as the MNL model assumes. When this is assumed, it is assumed that every observation provides the same amount of information for the estimation of parameters, while this is not the case. Standard errors of parameters are underestimated and t-values overestimated, which can lead to parameters that are not significant becoming significant. Ignoring taste heterogeneity can have the same effect.

The absolute values of the parameters are larger in the panel ML model compared to the MNL model. This can be explained as follows. The sigma's that were estimated in the ML model accommodate part of the unobserved heterogeneity. This 'eats away' from the i.i.d. error variance of the MNL model. Since this error variance is normalized, this leads to larger values of the parameters.

6.3.3 Model fit

The initial log likelihood of the ML model was -3328.795 and the final log likelihood was -2195.522. The adjusted rho-squared of the model is 0.330. This means that that 33% of the initial uncertainty is explained away by the model. Capturing panel effects led to a very large increase in model fit. This indicates that choices of individuals are strongly correlated. So, there are certain preferences of individuals that echo through in all choices made by that individual. Adding the sigma's to allow random taste heterogeneity for the attributes of the alternatives led to a significant, but relatively small further increase in the adjusted rho-squared. Of the socio-demographic variables, mobility habits and attitudes, only the addition of attitudes regarding TPC turned out to significantly increase the model fit.

6.3.4 Public's preferences regarding design variables of TPC

We are interested in the public's preferences regarding the design variables of TPC, so regarding the recipients of credits, the distribution principle, the allocation interval and the credit price fluctuation. The choice model presented in Section 6.3.1 included the choice between three alternatives: TPC1, TPC2 and opt-out. It is also possible to estimate a choice model that only includes the choice between TPC1 and TPC2. This provides more observations on how respondents weigh the systems against each other and might therefore lead to more reliable estimates. On the other hand, respondents who vote against the introduction of TPC in the second question may not make a well-considered decision when choosing between TPC1 and TPC2. This may lead to more randomness in the choices which may lead to less reliable parameter estimates. Both models are estimated and results were compared. The model with only TPC1 and TPC2 as alternatives has a lower rho-squared and the standard errors of parameters are all higher or nearly equal compared to those of the model in Section 6.3.1. Therefore, the model from Section 6.3.1 is used here to interpret the public's preferences regarding the design variables of TPC. Since effects coding is applied, the average utility contribution of each design

variable is set to zero. The utility contribution of each level expresses the utility derived from that level compared to the average utility contribution of that design variable, if everything else is kept constant.

Alternative specific constant TPC

Since attitudinal variables are part of the model, it is hard to interpret the TPC constant. In the model where only attributes of the alternatives were included in the utility function, the TPC constant was however also negative and significant, which indicates that on average there is a preference for maintaining the current situation compared to introducing TPC. The sigma of the TPC constant (-3.42) shows that there is a very high level of heterogeneity in unobserved preference for TPC alternatives compared to maintaining the current situation. The probability density function of the TPC constant is presented in Figure 6.4. This shows that the amount of utility respondents associate with TPC that cannot be explained by observed variables has a very wide range, and that both negative and positive values occur in that range.

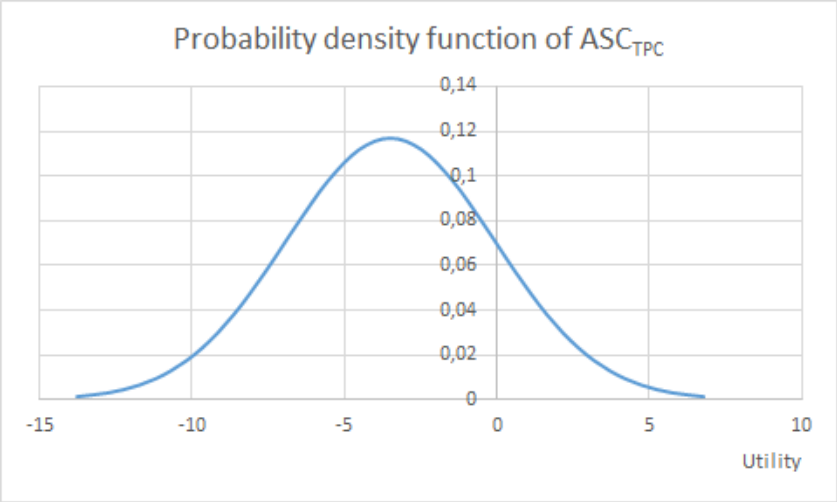


Figure 6.4: Probability density function of the alternative specific constant for TPC alternatives

Recipients of credits

Residents municipality + people who work there and own a car is preferred by the sample as group of people to receive free credits. After this, *Residents municipality who own a car* has the highest preference, followed by *Residents municipality + people who work there*. These two levels are not valued significantly different from the average utility retrieved from this attribute. Only *Residents of the municipality* receiving free credits is the least preferred of the four studied levels. There is however a significant amount of taste heterogeneity for this last option. This means that opinions differ about the option to only give credits to residents of the municipality.

When only *Residents of the municipality* would receive credits, it is preferred by the sample that only residents in possession of a car receive credits. So there is little support for also giving credits to people who probably hardly ever go by car, and thus rewarding them for the fact that they already show the desired behavior of not driving during peak hours. Furthermore, there is a preference for not only giving credits to residents, but also to people working in the municipality. There is however an even stronger preference for only giving them credits if they own a car. The reason for this is probably that respondents think that employees should only receive credits if they need them; so, if they travel to work by car. If employees do not have a car and thus probably not travel to work by car, they should not be entitled to receive credits.

There is significant heterogeneity in taste for the option to only give credits to residents of

the municipality. This means that respondents are very heterogeneous in the amount of utility they derive from this option. As can be seen in Figure 6.6, the β can take both positive and negative values. So on average the utility of a TPC system declines when only residents of the municipality receive credits, however, there are also respondents for who the utility of the TPC system increases when this is the case. There is no significant heterogeneity in taste for the other recipient options.

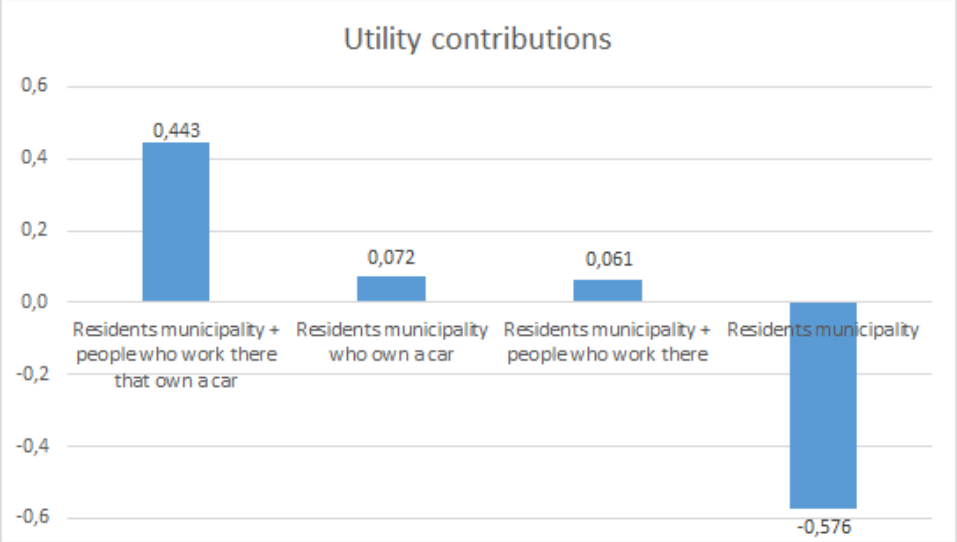


Figure 6.5: Utility contributions of the levels of 'Recipients of free credits' attribute

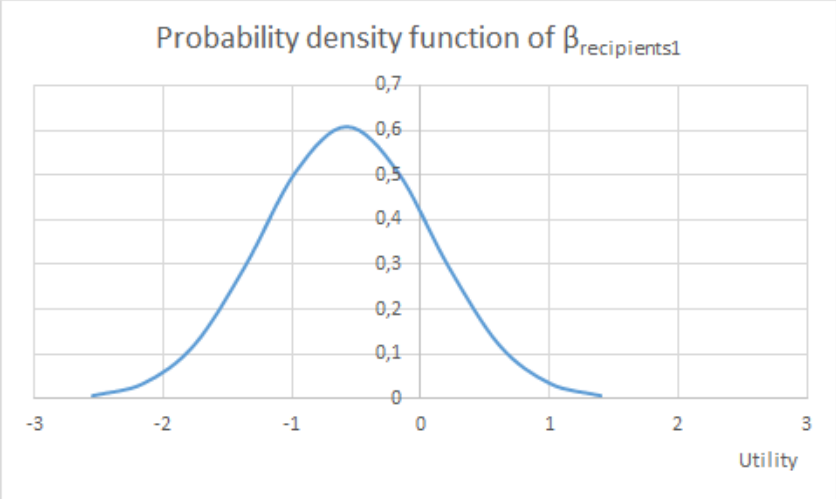


Figure 6.6: Probability density function of the β for recipients 1 (Residents municipality)

Distribution principle

Equal distribution of credits is the distribution principle that is most supported by the sample. This principle is probably considered the most fair by respondents. The principle with the second highest support is *people driving more kilometers receiving more credits*. The next principle in terms of support is that *people who work more hours receive more credits than people who work less hours*. The most unsupported distribution principle is *giving more credits to people with lower incomes*. This indicates that there is a lack of support for TPC as a leveling tool, so as a tool to redistribute welfare. So, there is considerably more support for equal distribution of credits than for distribution based on some condition. If the distribution would be based on a condition, the amount of kilometer travelled had the highest support.

The reasoning behind giving people who travel more kilometer more credits, and giving people who work more hours more credits, is that people who probably need more credits should also receive more credits than people who need them less. The model shows that it is valued higher if the distribution is based on amount of kilometers travelled instead of amount of hours worked. It is expected that the reason for this is that people think that you are also entitled to credits if you drive during peak hours for reasons other than work. For example, people can also drive during rush hour for informal care or volunteering. The principle that credits are distributed on the basis of kilometers driven takes this into account, while the principle that credits are distributed on the basis of hours worked only takes into account paid work. Another reason for the higher support for distribution based on the number of kilometers driven than hours worked might be that people find the amount of kilometers driven a better measure for how often a person has to drive during rush hour than the amount of hours someone works.

The probability density functions of the β's of the distribution principles are presented in Figure 6.8. There is significant heterogeneity in taste for all the distribution principles. All β's can take on both negative and positive values. To illustrate what this means: even though the mean value for β for equal distribution is positive, there are also respondents who have a negative value for this β. So on average the utility of TPC increases when credits are equally distributed, however, there are also respondents for who the utility of TPC declines when this is the case. This indicates that the opinions are very divided about which distribution principle should be applied. The utility respondents associate with the principle that people who work more hours receive more credits is the most heterogeneous.

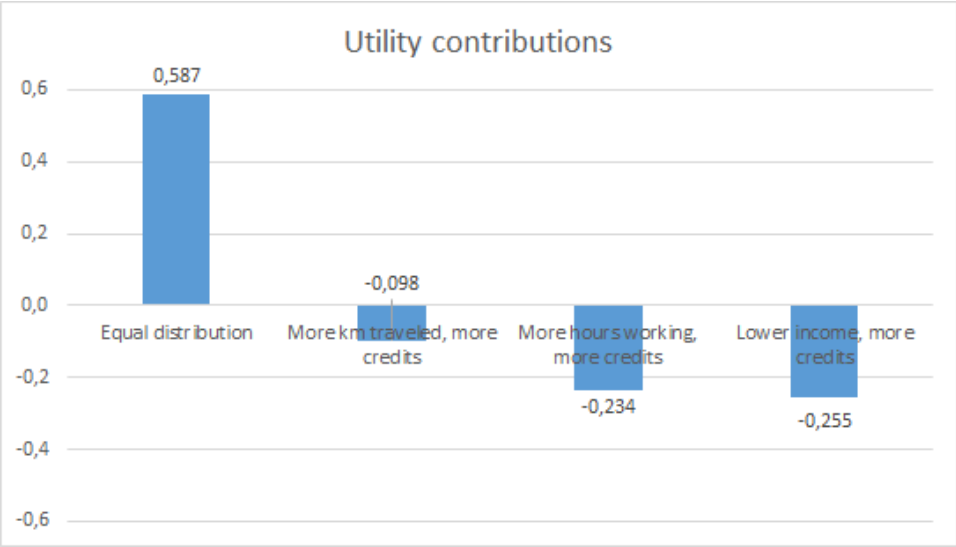
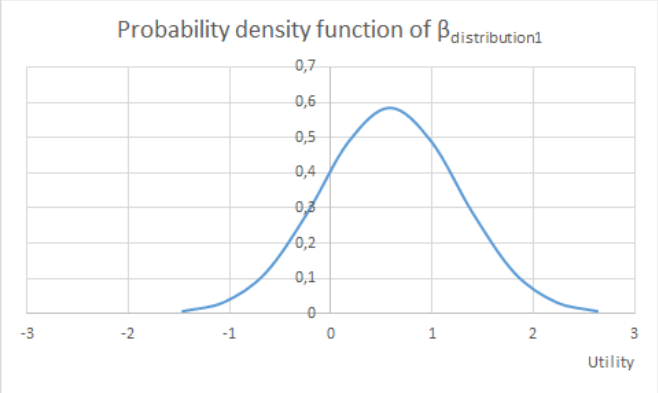
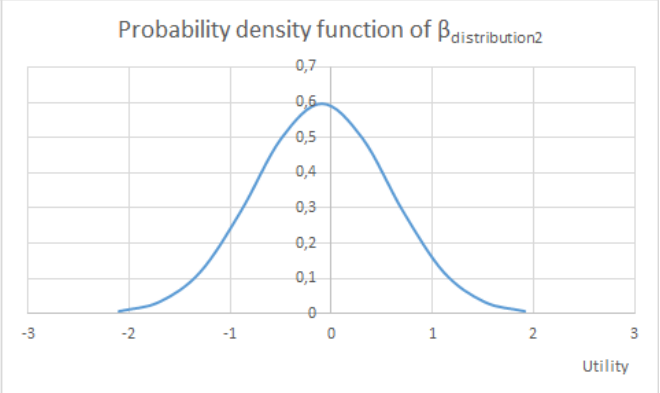


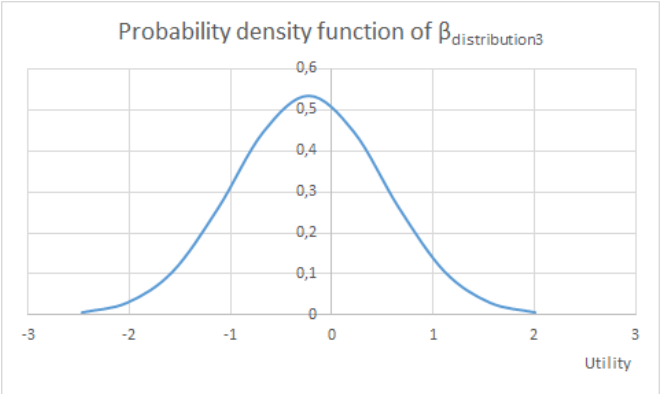
Figure 6.7: Utility contributions of the levels of 'Distribution principle' attribute



(a) Distribution 1: equal distribution



(b) Distribution 2: more kilometer traveled, more credits



(c) Distribution 3: more hours working, more credits

Figure 6.8: Probability density functions of the β's for the distribution principles

Credit allocation interval

Receiving credits every week is valued lower than receiving credits every month. A possible explanation for this is that respondents expect that they need to trade credits less often when they receive credits for a month, compared to for a week. Having to trade credits less often is expected to be appreciated by respondents, since trading requires some human effort. There is no significant heterogeneity in taste for credit allocation interval.

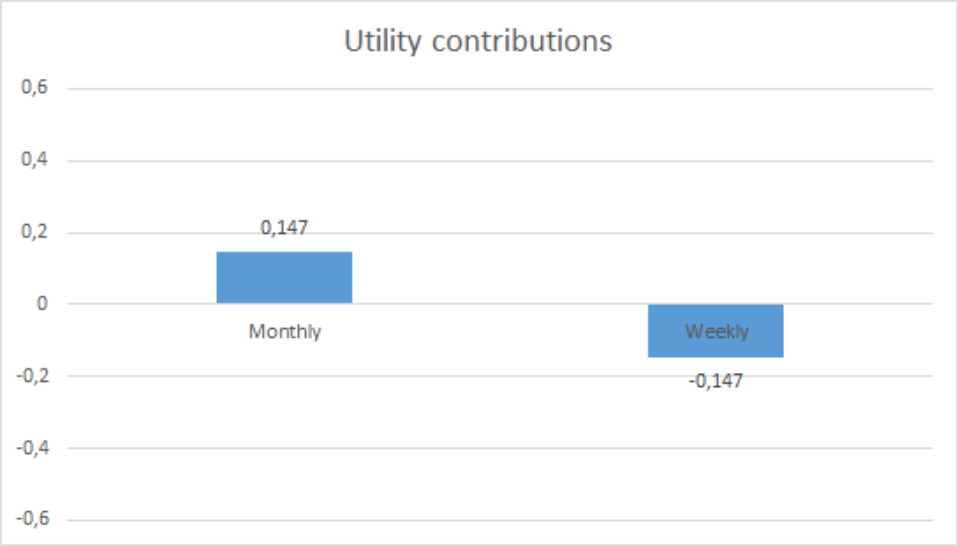


Figure 6.9: Utility contributions of the levels of 'Credit allocation interval' attribute

Price fluctuation

As expected, respondents prefer a lower frequency of credit price fluctuations. This is probably because people do not like uncertainties. When the price changes more often, they are less sure of how much they have to pay for a credit or can earn from selling a credit. There is no significant heterogeneity in taste for credit price fluctuation.

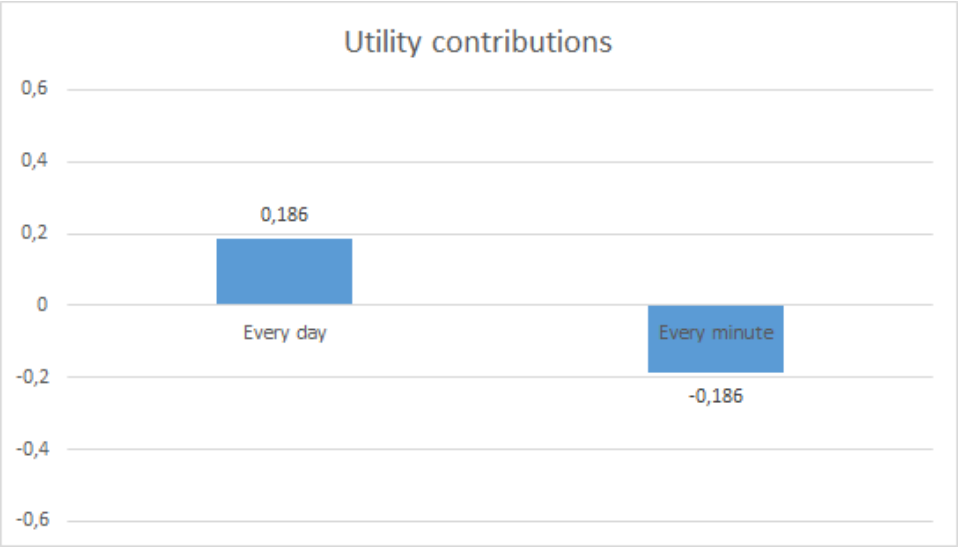


Figure 6.10: Utility contributions of the levels of 'Credit price fluctuation' attribute

6.3.5 Influence of socio-demographic variables and mobility habits

Of the socio-demographic variables that were added to the ML model, none turned out to have a significant influence on the utility of TPC. So, gender, age, educational level, working situation, whether someone has a license or not, and whether someone has children living at home or not do not have a significant influence on the choice for or against TPC. The effect of income could not be investigated, since there were too many missing values. Therefore, no statements can be made about the variable income. The included interaction effects were not significant. So, older people do not value credit price fluctuation significantly different from younger people. People with lower incomes do not value the distribution principle 'People with a lower income receive more credits than people with a higher income' significantly different from people with a higher income. Furthermore, people with a paid job do not value the distribution principles 'People who have traveled more km will receive more credits.' and 'People who work more hours per week receive more credits than people who work less hours per week.' significantly different from people who do not have a paid job. Also, people who have children living at home do not value the distribution principle 'People who have traveled more km will receive more credits.' significantly differend from people who do not have children living at home.

As discussed in Section 6.2.1 the sample turned out to be unrepresentative for the population in terms of gender, age andeducational level. However, since these socio-demographic variables do not significantly influence support levels, these deviations from the population did not influence support level. Therefore, the support levels for TPC as found in the sample are good predictors for the population. Here it is assumed that no systematic recruitment effects have occurred that have ensured that members of the panel are not representative of non-panel members.

Also none of the mobility habits that were included influenced the utility of TPC significantly. So, whether the car is someone's main mode of transport, whether someone has commute travel expenses that are not being reimbursed, the weekly number of trips during rush hour and the weekly number of trips during rush hour where there is congestion do not significantly influence the choice for or against TPC. Also the included interaction effects were not significant. So people who drive more often (during or not during rush hours) do not value the distribution principle 'People who have traveled more km will receive more credits.' significantly different than people who drive less often.

6.3.6 Influence of attitudes

Various attitudes regarding TPC of respondents turned out to affect the utility of TPC for them. All these influences are in the expected direction. The variables are discussed in order of how much effect they have on the utility of TPC, starting with the variable that has the largest effect. Respondents are more in favor of introducing TPC when:

- They consider TPC a fair system;
- They believe that TPC can effectively reduce the impact of car use on the environment;
- They trust that TPC is feasible and that the government is able to implement and maintain the system;
- They do not perceive TPC as an infringement on their personal freedom;
- They expect the trading of credits to be fun;

The other tested attitudes have no significant influence on the choice for or against the introduction of TPC. Whether respondents expect the trading of credits to be fun thus does influence the choice for or against the introduction of TPC, while the effort that respondents

expect the trading to take does not. Whether the system seems fun to them therefore plays a greater role than how much effort they think interaction with the system will require. Furthermore, the opinion that TPC infringes your personal freedom plays a role in the preference for or against TPC, while the opinion that it violates privacy does not. The opinion to what extent congestion is a problem for the environment and the economy has no significant influence on the choice for or against TPC, but the opinion about whether TPC can reduce the impact of cars on the environment does. Also the opinion about whether TPC can reduce congestion is expected to influence the choice for TPC as will be discussed in the next paragraph. So, the measured attitudes towards car-use in general did not play a significant role, only attitudes regarding TPC specifically did. Finally, how complicated respondents find TPC and how easy they can find alternatives for rush-hour car journeys do not significantly affect the choice for or against TPC.

The correlation between whether respondents think TPC can reduce congestion and whether respondents think TPC can reduce the impact of cars on the environment have a very high correlation (0.813). As a result, the model may have difficulty in distinguishing the effects of these variables. This can lead to biased and unreliable parameters. Therefore, first a model was estimated with only one of these variables, and then one with the other variable. In both models the coefficient then became significant, while in a model with both variables the coefficients did not become significant. It was chosen to include the variable with the highest t-value, which was the perceived effectiveness on the environment. The perceived effectiveness on congestion thus also probably influences the utility of TPC, but cannot be included in the model and therefore the precise relation cannot be determined.

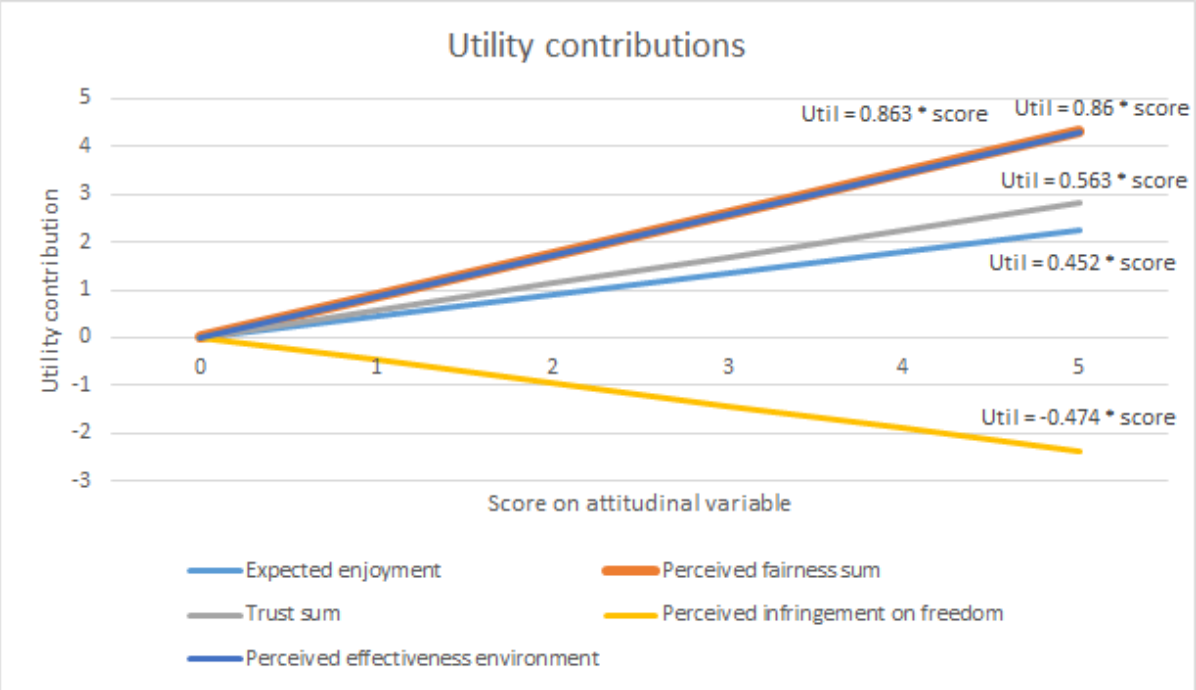


Figure 6.11: Utility contributions of attitudinal variables part

6.3.7 Importance of explanatory variables

The estimated coefficients of the variables are a proxy for the importance of the variables. However, it is not possible to determine which variables contribute most to utility of TPC by comparing the coefficients, due to the differences in the range of values that the variables can

take. For every variable with a significant coefficient it was determined what their potential contribution to utility of TPC is based on the coefficients and the value ranges. This is presented in Table 6.7. However, the importance of variables is still difficult to compare on the basis of the utility contribution range, because this also depends on the range in values chosen for a variable.

It is possible to compare the utility contribution ranges of the attitudinal variables with each other because they are measured on the same scale. Whether respondents consider a TPC system fair and whether they think TPC can effectively reduce congestion are the attitudes that influence support for TPC the most. An interesting outcome is that whether respondents trust that TPC is feasible and that the government is able to implement and maintain the system, and whether they expect the trading of credits to be fun, are also very important for the choice for or against TPC. This is interesting, since the importance of this attitude was not highlighted in the current literature on tradable credits.

The attributes of the alternatives can also be compared with each other. Only considering these attributes, who receive credits (recipients) influences the choice for or against the introduction of TPC the most. How credits are distributed among them (distribution principle) is less, but also still very important for this choice. How often the price of a credit changer (price fluctuation) and how often credits are allocated to recipients (allocation interval) play a smaller role. A higher price fluctuation has a stronger negative effect on the value of TPC than a smaller allocation interval. So how often the price can change is more important to respondents than how often they receive credits.

Based on the utility contribution ranges, the attitudes towards the system seem much more decisive for respondent's choice for or against TPC than the specific design of the TPC system.

Table 6.7: The relative importance of variables

Variables	**Coëfficiënt**	**Minimum value**	**Maximum value**	**Utility contribution range**	**Relative influence of attributes of the alternatives**
Attributes of the alternative					
Recipients	-	-	-	1.019	40.30%
Distribution principle	-	-	-	0.842	33.30%
Price fluctuation	-0.186	-1	1	0.372	14.70%
Allocation interval	-0.147	-1	1	0.294	11.60%
Attitudes regarding TPC and car use					
Perceived fairness sum	0.863	1	5	3.452	
Perceived effectiveness environment	0.860	1	5	3.340	
Trust	0.563	1	5	2.252	
Perceived infringement on freedom	-0.474	1	5	1.896	
Expected enjoyment	0.452	1	5	1.808	

6.4 Support for introduction of TPC, a congestion charge and a kilometer charge

The support of respondents for three different pricing instruments aimed at reducing congestion was measured in the questionnaire: TPC, a congestion charge and a kilometer charge. This was measured by asking respondents to what extent they are in favor of the introduction of each of these measures. Respondents could answer on a scale of 1 (completely against) to

5 (completely in favor). The results are shown in Table 6.8. In the discussion that follows, answers 4 and 5 are considered as supporting the measure, answers 1 & 2 as not supporting the measure and answer 3 as being undecided.

TPC is the measure with the lowest support, namely 26.5%. The support for a congestion charge, 28%, is only slightly higher. The introduction of a kilometer charge is most supported, with a support level of 35%. With all measures, there is still a fairly large group that state that they are not in favor and not against the introduction of the measure. For TPC 22.5% of respondents indicated this. This indicates that there is still a lot to gain in terms of support for TPC.

Table 6.9 presents the correlations between the support for TPC, congestion charge and kilometer charge. All correlations are significant and positive. This means that if the support for one measure increases, the support for the other measures also increases. If the support for one measure decreases, the support for the other measures also decreases. The relationship between support for TPC and support for a congestion charge is the strongest. This could be explained by the fact that these measures have in common that they focus only on peak hours.

Table 6.8: Statistics on the support for TPC, congestion charge and kilometer charge

Statistics		**TPC**	**Congestion charge**	**Kilometer charge**
Answer categories	Completely against (1)	35%	32%	34%
	Somewhat against (2)	16%	18%	11%
	Neither in favor nor against (3)	22.50%	22%	21%
	Somewhat in favor (4)	19.50%	18%	20%
	Completely in favor (5)	7%	10%	15%
Average		2.48	2.57	2.7
St. dev.		1.33	1.37	1.47

Table 6.9: Correlations between the support for TPC, congestion charge and kilometer charge

		Support TPC	**Support congestion charge**	**Support kilometer charge**
Support TPC	**Pearson correlation**	1	0.427	0.252
	Sig. (2-tailed)		0.000	0.000
Support congestion charge	**Pearson correlation**	0.427	1	0.545
	Sig. (2-tailed)	0.000		0.000
Support kilometer charge	**Pearson correlation**	0.252	0.545	1
	Sig. (2-tailed)	0.000	0.000	

Implications of the unrepresentativeness of the sample

The sample turned out to be unrepresentative for the population in terms of gender, age and educational level. As discussed in Section 6.2.2, if these characteristics influence support levels, then the support levels based on the sample may not be good predictors of support levels in the population. It must therefore be tested whether gender, age and educational level influence the support for TPC, congestion charge and kilometer charge and to what extent. Multiple regression analyses are performed with support on a scale of 1 to 5 as the dependent variable, and gender, age and educational level as independent variables. Gender and educational level are coded as presented before in Table 6.1. Results of the regression analyses are presented in Table 6.10. Appendix N checks whether the conditions for performing a regression analysis are met.

The coefficients for gender, age and educational level are not statistically significant in the model with support for TPC as dependent variable. This was expected, as these variables were also not significant in the ML model as discussed in Section 6.3.5. Therefore, the support levels for TPC as found in the sample are good predictors for the population.

In the model with support for congestion charge as dependent variable, the coefficients for educational level and gender are significant at the 5% significance level. Support for a congestion charge increases with higher educational levels. In the sample, the high and low educational levels are underrepresented almost equally; the low educational levels are slightly more underrepresented. As a result, it is expected that these influences will cancel each other out to a large extent. Furthermore, the support for a congestion charge is lower among women compared to men. Women are overrepresented in the sample compared to the population. It was tested to what extent these differences between the sample and the population influence support levels with regression analyses. It was not possible to compare support for the sample and the population based on a regression model with both educational level and gender as independent variables, as it is unknown for the population how educational level and gender are related. Therefore, two separate regression analyses are performed: one with only educational level as independent variable (see Table 6.11) and one with only gender as independent variable (see Table 6.12). Here educational level is coded into only three levels (low, medium and high) since this information is available about the population, and not the more detailed educational levels. Based on the percentages of the educational levels and gender in the sample and in the population (see Appendix K), the mean support levels could be computed based on these regression models. It can be seen that the support levels in the sample and population hardly differ based on both regression models. Therefore, it is expected that the support levels for congestion charge based on the sample are a good predictor for the population. The exact same applies to the support for a kilometer charge. There only the coefficient for educational level is significant. Here again the mean support level was calculated for the sample and the population and this showed that these again hardly differed (see Table 6.11). Therefore, it is also expected that the support levels for kilometer charge based on the sample are a good predictor for the population. Concluding: although the sample is unrepresentative for the population in terms of gender, age and educational level, the calculated support levels for TPC, congestion charge and kilometer charge based on the sample are still good predictors for the population.

Table 6.10: Results regression analysis support TPC, congestion charge and kilometer charge

	Support TPC		**Support congestion charge**		**Support kilometer charge**	
	Unstandardized coefficient	**T-value (p-value)**	**Unstandardized coefficient**	**T-value (p-value)**	**Unstandardized coefficient**	**T-value (p-value)**
Constant	2.167	7.543 (0.000)	2.096	7.185 (0.000)	2.008	6.370 (0.000)
Gender	0.059	0.957 (0.339)	0.128	2.035 (0.042)	0.095	1.396 (0.163)
Age	0.002	0.538 (0.591)	-0.002	-0.413 (0.680)	0.003	0.795 (0.427)
Educational level	0.053	1.288 (0.198)	0.133	3.185 (0.002)	0.128	2.842 (0.005)

Table 6.11: Results regression analysis congestion charge and kilometer charge with only educational level as independent variable

	Support congestion charge				Support kilometer charge			
	Unstandardized coefficient	**T-value (p-value)**	**Mean support based on sample of 100**	**Mean support based on population of 100**	**Unstandardized coefficient**	**T-value (p-value)**	**Mean support based on sample of 100**	**Mean support based on population of 100**
Constant	1.967	9.107 (0.000)	2.563	2.561	2.231	9.574 (0.000)	2.697	2.695
Educational level (1=low, 2=medium, 3=high)	0.248	2.890 (0.004)			0.194	2.094 (0.037)		

Table 6.12: Results regression analysis congestion charge with only gender as independent variable

	Support congestion charge			
	Unstandardized coefficient	**T-value (p-value)**	**Mean support based on sample of 100**	**Mean support based on population of 100**
Constant	2.577	41.892 (0.000)	2.561	2.576
Gender	0.103	1.678 (0.094)		

6.5 Summary of main results

- There is a high level of unobserved heterogeneity in the preference for introducing TPC compared to maintaining the current situation. This is a like or dislike for TPC that people have that cannot be explained by the observed variables. This means residents of transport regions Amsterdam and Utrecht are very heterogeneous in liking or disliking TPC in general.
- There is a preference for also giving credits to people who work but not live in the municipality, instead of only giving credits to residents of the municipality. It is however even stronger preferred that when those employees also receive credits, only the employees who own a car receive them. When only residents of the municipality would receive credits, it is also preferred that only residents in possession of a car receive credits. So there is little support for also giving credits to people who probably hardly ever go by car, and thus rewarding them for the fact that they already show the desired behavior of not driving during peak hours.
- Equal distribution of credits is the preferred distribution principle. The principle with the second highest support is people driving more kilometers receiving more credits. The next principle in terms of support is that people who work more hours receive more credits than people who work less hours. The most unsupported distribution principle is giving more credits to people with lower incomes. This indicates that there is a lack of support for TPC as a tool to redistribute welfare. There is significant heterogeneity in taste for all the distribution principles. This indicates that the opinions are very divided about which distribution principle should be applied.
- People prefer to receive credits every month over receiving them every week.
- People prefer the price of a credit to change once every day instead of once every minute.

- Who receive credits and how credits are distributed influence the support for TPC to a larger extent than how often credits are distributed and how often the credit price changes.
- Socio-demographic variables and mobility habits do not significantly influence the support for introducing TPC.
- Several attitudes regarding TPC of people do influence the support for introducing TPC. People are more in favor of introducing TPC when:
  -They consider TPC a fair system;
  -They believe that TPC can effectively reduce the impact of car use on the environment;
  -They trust that TPC is feasible and that the government is able to implement and maintain the system;
  -They do not perceive TPC as an infringement on their personal freedom;
  -They expect the trading of credits to be fun.
- The support for TPC is 26.5% and is therefore almost equal to the support for a congestion charge (28%). A kilometer charge is most supported, with a support level of 35%.

7

Results - Influence of medium and content of the introduction of stated choice experiments

As explained in Section 5.3.4, two aspects of the introduction to TPC that respondents received were varied in the survey: the type of information included in the introduction of TPC and the medium through which the information was presented to respondents. RQ 2 aims to investigate the influence of these variations in the introduction on drop out (Section 7.2), on preferences observed via choice behavior (Section 7.3) and on attitudes regarding TPC and the survey (Section 7.4). The underlying objective is to determine to what extent researchers' choices in setting up the introduction in their stated choice experiment influence the outcomes. This way, a step is taken in evaluating the validaty of results obtained with stated choice experiments.

7.1 Descriptive results

Ideally each survey version would be completed by the same amount of respondents, since this leads to the same amount of observations for each variation. The survey was programmed in such a way that this was the case. However, due to respondents dropping out during the survey, not every version of the survey is completed by the same amount of respondents. Slightly more respondents received the introduction to TPC via text (54%), compared to video (46%). Also slightly more respondents received the introduction that included information type 'Explanation TPC' (54%) compared to information type 'Explanation TPC & problem' (46%). There are enough observations of all variants to investigate their influence on outcomes.

7.2 Influence of introductions on drop out

In total, 375 people opened the survey but did not complete it. When accounting for people opening the survey multiples times, 372 unique people did open but not complete the survey. Of these people dropping out, exactly half received the introduction to TPC via video and the other half via written text. The drop out therefore was not greater when receiving a video instead of text, or the other way around. However, there was a clear difference in the moment of dropping out between these two groups (see Table 7.1). Of the people dropping out before even starting to read or view the introduction to TPC, the vast majority had the video.

So there seem to be many people who do not want to or cannot start watching the video. A possible reason for this is that watching a video costs relatively much data compared to reading text. This may have created a threshold for people. It is also possible that people thought you needed sound to watch the video (while this was not the case because it was subtitled). This may also have created a threshold in for example public places. It is also possible that people simply do not want to watch video, even if these practical objections do not play a role. In conclusion, there was a high amount of drop out among people who received the video, which is expected to be mainly caused by practical issues. When looking at the people dropping out after reading or viewing (part of) the introduction, it is interesting to note that the opposite occurs: here the vast majority had the written text. So, once people have started the introduction, they complete it more often and continue with the survey more often if they received the introduction via a video instead of written text. So, once people have started watching the video, this medium causes less dropout than text does.

In general, the majority of the drop out, 86.9%, occurs before people started answering questions. Only 13.2% of the people dropping out did so during the answering of questions. The introduction to the survey therefore mainly led to drop out. What are possible reasons for the high drop out in this study and how could this have affected the sample? First of all, drop out can be caused by the announced length of the survey. This may have caused an overrepresentation of people with relatively much free time and an underrepresentation of busy people. Secondly, the subject of the survey may have caused drop out. It is possible that people dropped out because they found the subject complex, not interesting, or because they were very opposed to the idea of TPC. This may have caused an overrepresentation of people who understand TPC well, and of people who find the subject interesting and have a strong opinion (either positive or negative) about it that they want to share. Thirdly, dropout may be caused by practical problems regarding watching a movie as discussed before.

Table 7.1: The moment of people dropping out of the survey

Moment of dropping out	**Total amount**	**Text introduction**	**Video introduction**
Before starting to read or view the introduction to TPC	158 (42.5%)	34 (9.1%)	124 (33.3%)
After reading (part of) the introduction to TPC, before starting on the choice sets	165 (44.4%)	119 (32.0%)	46 (12.4%)
After completing (part of) the choice sets, before starting the questionnaire	21 (5.6%)	13 (3.5%)	8 (2.2%)
During the questionnaire	28 (7.5%)	20 (5.4%)	8 (2.2%)
Total	372 (100%)	372 (100%)	

7.3 Influence of introductions on choice behavior

In Section 6.3 choice models were estimated that modelled the choice between the introduction of a TPC system and maintaining the current situation. Various variables were included in the model, and turned out to influence the choice. Also a variable was included that indicated whether respondents received information type 'Explanation TPC' or 'Explanation TPC & problem', and a variable was included that indicated whether respondents received the information via text or via a video. The model estimation results relating to these variables are presented in Table 7.2. The question was whether the elements that were varied between the

introductions had a significant influence on the preferences of the respondents in the stated choice experiment.

Table 7.2: Estimation results choice context variables

Attribute	**MNL-model**			**ML-model**		
	Coëfficiënt	**Standard error**	**T-value (p-value)**	**Coëfficiënt**	**Standard error**	**T-value (p-value)**
Choice context variables (introduction versions)						
Information type introduction	-0.0733*	0.0431	-1.70 (0.09)	-0.258*	0.183	-1.41 (0.159)
Medium introduction	0.0985	0.0434	2.27 (0.02)	0.245*	0.178	1.38 (0.168)
*Not significant at 95% significance level						

Respondents who not only read about how the TPC systems works, but who also read about the underlying problem that TPC should reduce (information type 'Explanation TPC & problem') valued TPC alternatives higher than respondents who only read about how the TPC systems works (information type 'Explanation TPC'). This was expected, since it was hypothesized that people who have the problem and the extent of the problem in mind are more positive towards a solution to the problem. The difference was however not significant.

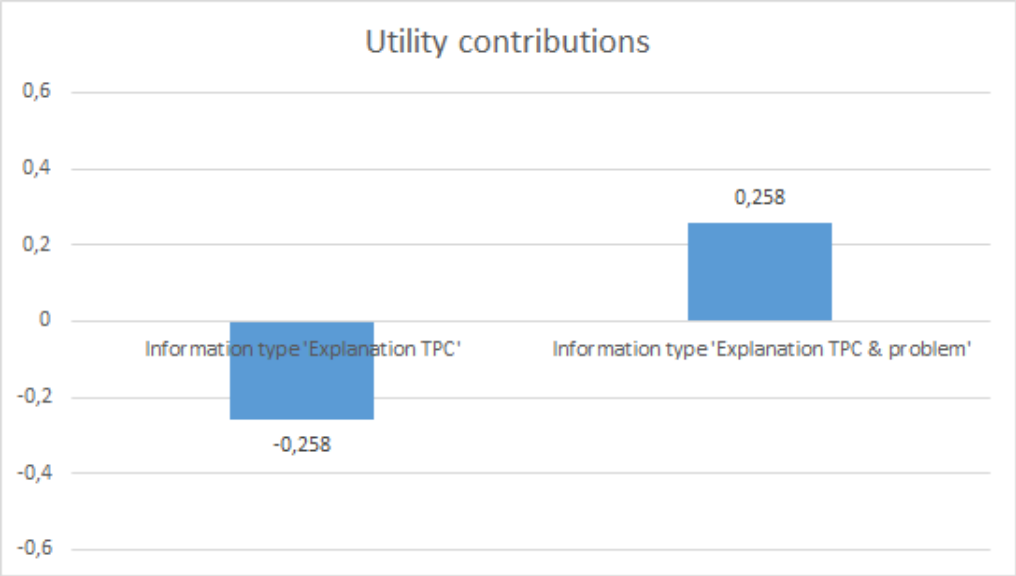


Figure 7.1: Utility contributions of the levels of 'Information type introduction' variable

Respondents who received the introduction of TPC via a video instead of written text valued TPC higher than respondents who read that same introduction, as Figure 7.2 shows. Being introduced with the measure via a video instead of via a text thus made respondents more positive about the measure. However, this effect was also not significant.

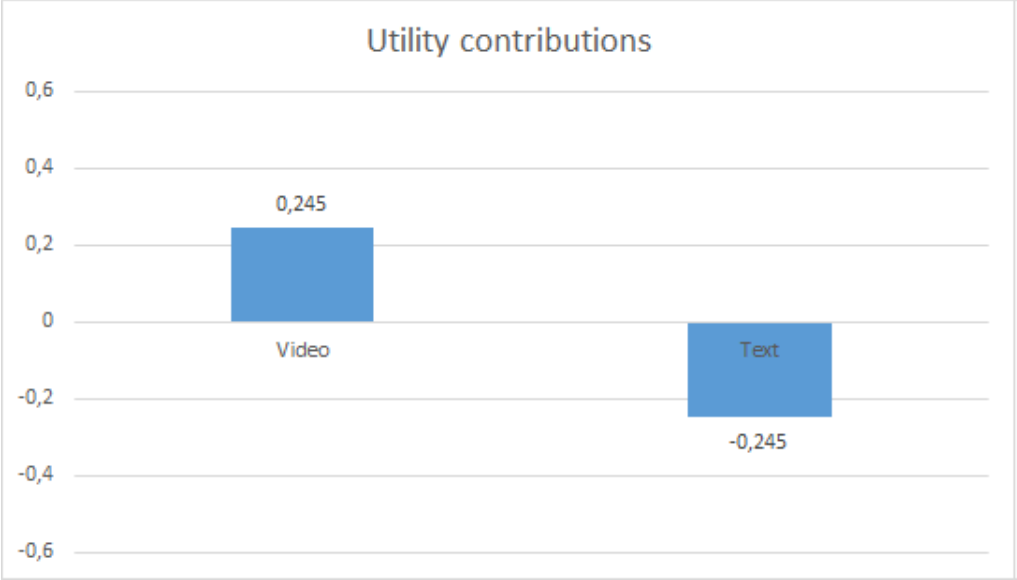


Figure 7.2: Utility contributions of the levels of 'Communication medium introduction' variable

7.4 Influence of introductions on attitudes regarding TPC and the survey

This section will examine the influence of introduction context and medium on the attitudes of respondents regarding TPC and the survey.

7.4.1 Influence of the type of information included

We are interested in finding out whether the type of information read by the respondent('Explanation TPC' or 'Explanation TPC & problem') influences his attitudes regarding TPC. It is hypothesized by emphasizing the congestion problem and the negative consequences of congestion, respondents are more positive towards TPC, since it is a measure that can reduce these problems. In order to test this hypothesis, the influence of the type of information on the following constructs is analyzed: problem perception congestion, expected personal outcome, support for the introduction of TPC directly after having read the introduction of TPC. Independent sample t-tests were used for this and results are reported in Table 7.3. The results of these tests show that there are no significant differences between the two groups of respondents in the extent to which they perceive congestion as a problem, in the extent to which they expect TPC to have positive outcomes for them, and in the extent to which they support the introduction of TPC.

The survey also included a manipulation check. At the end of the survey, respondents were asked whether they read about the negative consequences of traffic jams in the introduction of TPC (information that was only part of information type 'Explanation TPC & problem'). They could answer 'yes', 'no' or 'I do not remember'. This question checks whether respondents consciously read the information in the introduction that was varied. Table 7.4 shows the number of respondents who answered the question correct, wrong, and who answered that they did not remember. More than half of the respondents (53.3%) answered the question wrong or did not not remember. The majority of the respondents who answered the question wrong thought they had received information about the problem that TPC should reduce, while this was not the case. Under 'Interpretation of results' a possible explanation for this is discussed.

Table 7.3: Test for significant difference in attitudinal variable between groups of respondents

Attitudinal variable	**Group of respondents**	**Descriptive statistics**			**Independent samples t-test**		
		Mean	**St. dev.**	**Number**	**Difference**	**T**	**p (2-tailed)**
Problem perception congestion	Information type 'Explanation TPC'	3.73	1.031	271	0.159	1.732	0.084
	Information type 'Explanation TPC & problem'	3.89	1.024	234			
Expected personal outcome	Information type 'Explanation TPC'	3.04	1.336	271	-0.05	-0.407	0.684
	Information type 'Explanation TPC & problem'	2.99	1.41	234			
Support for the introduction of TPC	Information type 'Explanation TPC'	2.62	1.293	271	0.022	0.186	0.853
	Information type 'Explanation TPC & problem'	2.65	1.323	234			

In the previous statistical tests, all respondents were included, so also those who answered the manipulation check incorrectly (and therefore thought that they had read about the disadvantages of traffic jams while they had not done this or thought they had not read about the disadvantages of traffic jams while they were in fact part of the introduction) and those who did not remember. It is also possible to include only the respondents who have answered the manipulation check correctly. Then only respondents are included who were aware of what type of information was part of the introduction. In this way you prevent that respondents who received information type 'Explanation TPC & problem', but who did not actually read about the disadvantages of traffic jams, become part of the test whether adding information about disadvantages influences certain attitudes.

Therefore the aforementioned statistical tests were performed a second time, but this time only including the observations of respondents who answered the manipulation check correctly. The number of observations dropped from 505 to 236 as a result. Information type still does not have a significant influence on personal outcome and on support. It now does however have a significant influence on problem perception congestion, as can be seen in Table 7.5. The respondents who received information type 'Explanation TPC & problem' and thus were informed about the negative consequences of traffic jams, perceived traffic jams as more problematic than respondents who were not informed about this. So priming information can cause respondents to respond differently to a statement related to that information than respondents where the information was not primed. This means that what information is included in a survey can influence the results of the survey.

Table 7.4: The amount of respondents that answered the manipulation check correctly, wrongly and that answered that they did not remember

Information type that respondent actually received	**Answer to manipulation check**			**Total**
	Correct	**Wrong**	**"I do not remember"**	
Information type 'Explanation TPC'	46 (9.1%)	174 (34.5%)	51 (10.1%)	505 (100%)
Information type 'Explanation TPC & problem'	190 (37.6%)	16 (3.2%)	28 (5.5%)	
Total	236 (46.7%)	190 (37.7%)	79 (15.6%)	505 (100%)

Table 7.5: Test for significant difference in problem perception congestion between groups of respondents (only respondents included who correctly answered the manipulation check)

Attitudinal variable	Group of respondents	Descriptive statistics			Independent samples t-test		
		Mean	St. dev.	Number	Difference	T	p (2-tailed)
Problem perception congestion	Information type 'Explanation TPC'	3,39	1,085	46	-0,609	-3,666	0
	Information type 'Explanation TPC & problem'	4	0,992	190			

Interpretation of results

Adding information to the introduction did not have a significant effect on two of the three tested attitudes. A first explanation for this is that there is simply no effect. Another explanation is that the added information is information that is already present with every respondent, and that therefore there was not actually a difference between the two groups of respondents. The consequences of traffic jams are fairly well known by people, so it may not matter whether they read about it in the introduction or not. An observation that supports this line of thought, is that 64% of the respondents who received no information about the negative consequences of traffic jams (information type 'Explanation TPC') answered the manipulation check wrongly and thus thought that they had read information of negative consequences of traffic jams. A reason for this might be that this information is present in their minds anyway. If this is the case, it is possible that adding information to the introduction of a concept will influence respondents' attitudes if the added information is unknown to respondents.

Adding information did significantly influence one attitude of respondents. This indicates that it is possible to influence an attitude by adding information to the introduction. However, important comments must be made here. First of all, adding information only influenced the attitude that was directly linked to the information that was added. In this case, adding information about the negative consequences of traffic jams only influenced the attitude how problematic traffic jams are. It did not influence attitudes that are less directly connected, such as support for a measure to reduce traffic jams. Secondly, the added information only influences people who consciously read the information in a way that they remember this at the end of the survey. The data from this research shows that a large part of the respondents did not remember this at the end of the survey. So it might often not be the case that respondents consciously read the entire introduction of concept in a survey. Thirdly, it is only tested whether added information influences an attitude if the attitude is measured quickly after reading the information. It has therefore not been investigated whether the attitude has changed over the long term. But even if the attitude does not change in the long term, it is an interesting insight if it does happen in the short term. If researchers unconsciously influence an attitude that they measure by adding certain information, their data on attitudes does not match the attitudes on a longer term.

7.4.2 Influence of the communication medium

In this section, the influence of the communication medium on attitudinal variables will be investigated. First of all, it was examined whether the medium used to explain TPC, text versus video, influences how clear respondents find the introduction of TPC. An independent sample

t-test was used. In the survey, respondents were given the statement "I found the explanation of tradable peak credits clear." and they could answer on a scale of 1 (fully disagree) to 5 (fully agree). The respondents who received the introduction to TPC in a video found the introduction slightly clearer (average of 4.09) than the respondents who received the introduction in text (average of 3.89). This difference is relatively small, but statistically significant ($p = 0.016$), as can be seen in Table 7.6.

Respondents were furthermore provided with two statements to measure the extent to which they perceive TPC as complicated ("I find tradable peak credits easy to understand." and "I find peak credit very complicated."). As explained in Section 6.1.2, these two statements were combined into one scale variable on which respondents score on a scale of 1 (considering TPC easy to understand) to 5 (considering TPC as complicated). Respondents who received the introduction to TPC in a video view TPC slightly less complex (average of 5.76) than the respondents who received the introduction in text (average of 5.89). This difference is however very small and not statistically significant ($p = 0.499$), as can be seen in Table 7.6.

Concluding, respondents who receive the introduction to TPC via a video instead of reading it perceive the introduction as slightly more clear. However, this does not mean that they think TPC is less complicated than the respondents who read about it.

Table 7.6: Test for significant difference in attitudinal variable between groups of respondents

Attitudinal variable	**Group of respondents**	**Descriptive statistics**			**Independent samples t-test**		
		Mean	**St. dev.**	**Number**	**Difference**	**T**	**p (2-tailed)**
Clarity of explanation of TPC	Video	4.09	0.965	233	-0.208	-2.412	0.016
	Text	3.89	0.971	272			
Perceived complexity TPC	Video	2.88	1.107	233	-0.065	-0.677	0.499
	Text	2.95	1.038	272			

8

Model application - Predicting support for TPC designs

Various scenarios have been drawn up of ways in which TPC could be implemented, that are considered realistic. For every scenario it is predicted what the support level would be for this TPC design. This is done by computing the probability that people would vote for the introduction of a certain TPC system design, using a choice model. Based on this, recommendations for the design of TPC can be provided which are especially useful for policy makers. This gives them insight into how the design of a TPC system influences support for that system. Section 8.1 will first discuss the choice model that is used to predict the support levels. Next Section 8.2 presents how support levels change when individual design variables change. Subsequently the choice model will be applied to all scenarios in Section 8.3. The results will be discussed in Section 8.4. Recommendation for policy makers are provided in Section 10.2.

8.1 Choice model used for prediction of support levels

A modified version of the panel ML choice model from Chapter 6 is used to predict the support levels. The ML model now only contains the attributes of the choice alternatives, and not the attitudes towards TPC. A reason to include the attitudes towards TPC is that the analysis in Chapter 6 showed that they do influence the choice for or against the introduction of TPC. Also, including them improved the model fit from 0.301 to 0.330, which means that the model that includes them will predict choices more accurately. However, a reason to not include the attitudes towards TPC is that policy makers who would use the model to predict support levels for a certain TPC design would generally not have knowledge on the attitudes in the population. Also it is unknown how the attitudes will develop, so attitudes can also not be predicted for the future. Including attitudes in the model would thus make it unusable for policy makers, except in a situation where they would again collect information on the attitudes towards TPC. It was therefore chosen to not include the attitudes in the model to predict support levels for TPC designs.

The choice model that was used is presented in Table 8.1. The interpretation of the influence of the attributes is equal to the interpretation discussed in Chapter 6. Based on this choice

model, choice probabilities will be computed that a person would choose for the introduction of a TPC system with a certain design over maintaining the current situation.

Table 8.1: Final model estimation results

Attribute	**ML-model**		
	Coëfficiënt	**Standard error**	**T-value (p-value)**
ASC Tradable Peak Credits	-0.484	0.133	-4.28 (0.00)
Attributes of the alternatives			
Recipients			
-R1 (Residents municipality)	-0.575	0.121	-4.74 (0.00)
-R2 (Residents municipality who own a car)	0.0711*	0.13	0.545 (0.59)
-R3 (Residents municipality + people who work there)	0.066*	0.0883	0.747 (0.46)
Distribution principle			
-D1 (Equal distribution)	0.598	0.111	5.4 (0.00)
-D2 (More km traveled, more credits)	-0.109*	0.132	-0.826 (0.41)
-D3 (More hours working, more credits	-0.221	0.0943	-2.34 (0.02)
Price fluctuation	-0.186	0.0621	-3.00 (0.00)
Allocation interval	-0.148	0.0425	-3.49 (0.00)
Sigma's of parameters			
Sigma Tradable Peak Credits	-4.59	0.319	-14.4 (0.00)
Sigma D1 (Equal distribution)	0.69	0.12	5.75 (0.00)
Sigma D2 (More km traveled, more credits)	0.701	0.108	6.49 (0.00)
Sigma D3 (More hours working, more credits	0.686	0.127	5.4 (0.00)
Sigma R1 (Residents municipality)	0.67	0.123	5.43 (0.00)
Log-likelihood (LL)	-2299.41		
Adjusted ρ^2	0.301		
* Not significant at 95% significance level			

8.2 Changes in support levels due to changes in design variables

The support levels for all 64 possible TPC designs were calculated. Based on this, it could be determined how a change in a design variable causes a change in the support for TPC. In Table 8.2 the average absolute changes in support levels are given when a certain design variable changes, provided that all other design variables remain the same. This provides insight into how much effect changing a design variable can have on support for the TPC design. This is a useful tool for policy makers. It shows that in particular a lot of support can be gained or lost due to choices regarding the recipients or credits and the distribution principle.

Table 8.2: The changes in support levels for TPC caused by changes in design variables

Change in design variable			**Average absolute change in support level**
Design variable	**Old level**	**New level**	
Recipients of credits	All residents of the municipality	All residents of the municipality who own a car.	+ 5.00%
		All residents of the municipality + people who work there.	+ 4.85%
		All residents of the municipality + people who work there and own a car.	+ 7.80%
Distribution principle	Credits are equally distributed among all recipients	People who have traveled more km will receive more credits.	- 5.57%
		People who work more hours per week receive more credits than people who work less hours per week.	- 6.44%
		People with a lower income receive more credits than people with a higher income.	- 6.64%
Credit price fluctuation	Every minute	Every day	+ 2.89%
Credit allocation interval	Weekly	Monthly	+ 2.30%

8.3 Scenarios on TPC designs

Section 8.2 provided insight into how individual changes in design variables increase or decrease support for TPC. This however does not yet provide insight into support levels for entire TPC designs. Therefore now several scenarios on the design of TPC will be discussed and support levels for those designs will be predicted. The TPC systems in the scenarios differ with regard to four design variables, which are shown in Table 8.3. In addition to the scenarios, the design with the highest and lowest support are also presented. This provides more insight into the extent to which the support levels depend on the design variables of TPC that are varied.

In Chapter 6 it was shown that people prefer receiving credits every month instead of every week and that people prefer the permit price fluctuating every day instead of every minute. However, it is unclear what the influence of the allocation interval and credit price fluctuation is on the effectiveness of TPC. Because this is unknown, the credit price fluctuation and allocation interval cannot be properly selected in the scenarios. It is possible to use the allocation interval and the credit price fluctuation that are preferred by the public in every scenario, however, future research may for example show that it is necessary to distribute credits every week in order to reduce traffic jams. In that case it is useful to also know the support levels when distributing credits every week. It has therefore been decided to base the scenarios on the recipients of credits and the distribution principle and the support levels for those scenarios are calculated for both possible allocation intervals and price fluctuations.

Table 8.3: The characteristics in which the TPC designs differ

Attribute	Levels
Credit allocation interval	Weekly Monthly
Eligible recipients of free credits	All residents of the municipality. All residents of the municipality who own a car. All residents of the municipality + people who work there. All residents of the municipality + people who work there and own a car.
Distribution principle	Credits are equally distributed among all recipients. People who have traveled more km will receive more credits. People who work more hours per week receive more credits than people who work less hours per week. People with a lower income receive more credits than people with a higher income.
Credit price fluctuation	Every minute. Every day.

8.3.1 TPC design with highest and lowest support

Based on the coefficients of the choice model, it could be determined which combination of design characteristics leads to the design with the highest and lowest support. Table 8.4 shows these designs and the support levels for these TPC systems.

Table 8.4: Support levels for TPC design with highest and lowest support

	TPC design with highest support	**TPC design with lowest support**
Eligible recipients of free credits	All residents of the municipality + people who work there and own a car	All residents of the municipality
Distribution principle	Credits are equally distributed among all recipients	People who work more hours per week receive more credits than people who work less hours per week
Credit allocation interval	Monthly	Weekly
Credit price fluctuation	Every day	Every minute
Support level	53.2%	33.8%

8.3.2 Scenario 1: Minimize intrusiveness and costs

The first scenario is the most simple form of a TPC system in terms of information that is required to distribute credits. In this design, only residents of the municipality where TPC is introduced would receive credits. For this it is only necessary to know who lives in a municipality, and not who owns a car and in which municipality people work. Credits would be distributed equally among recipients in this design. The other distribution principles involve distribution based on a characteristic of the recipients, which means that information regarding that characteristics is required about each recipient. So, only information that is already present at governments is needed for this system design. This makes it relatively easy to set it up. It also makes the system relatively cheap compared to other designs, since no information

needs to be collected and kept up-to-date. Also for privacy reasons, this system is expected to be the most feasible and the least intrusive. The support levels associated with this scenario are presented in Table 8.5.

Table 8.5: TPC design scenario 1

Eligible recipients of free credits	**Distribution principle**	**Credit allocation interval**	**Credit price fluctuation**	**Support level**
All residents of the municipality	Credits are equally distributed among all recipients	Weekly	Every minute	40.0%
		Weekly	Every day	42.9%
		Monthly	Every minute	42.2%
		Monthly	Every day	45.2%

8.3.3 Scenario 2: Acknowledge commuting

The second scenario has the same starting point as the first scenario, namely limiting the data required about users. Another starting point in this scenario is that people who work in the municipality should not be more affected by the system than people who live there. Therefore, people who work in the municipality but not live there should also receive credits, since they will often travel in the area during peak hours. By not giving them credits, they are strongly disadvantaged by the system which is considered undesirable in this scenario. This makes the region less attractive for employees, especially when TPC has not been introduced in other areas where they can work. This can be harmful to the local economy. The TPC design in this scenario is equal to the design in scenario 1, except that in this design both residents of the municipality and people who work in the municipality receive credits. It was chosen not to limit it to employees who have a car, since this requires the authority to collect this data. The support levels associated with this scenario are presented in Table 8.6. It can be seen that the support levels increase with approximately 5% compared to scenario 1 in absolute terms, due to also giving credits to people who work in the municipality but do not live there.

Table 8.6: TPC design scenario 2

Eligible recipients of free credits	**Distribution principle**	**Credit allocation interval**	**Credit price fluctuation**	**Support level**
All residents of the municipality + people who work there	Credits are equally distributed among all recipients	Weekly	Every minute	44.9%
		Weekly	Every day	47.9%
		Monthly	Every minute	47.2%
		Monthly	Every day	50.2%

8.3.4 Scenario 3: Redistribute welfare with TPC

As discussed by Brands et al. (2019), TPC can also be used to redistribute costs and benefits. The assumption in this scenario is that there is a desire to also use TPC to redistribute welfare. Giving people with a lower income more credits than people with a higher income can achieve this. The credits are again allocated to both residents of the municipality and people who work there. The support levels associated with this scenario are presented in Table 8.7. Support levels decrease by around 6.5% when TPC is used to redistribute welfare in absolute terms, compared to scenario 2 where this was not done and credits are distributed equally.

Table 8.7: TPC design scenario 3

Eligible recipients of free credits	Distribution principle	Credit allocation interval	Credit price fluctuation	Support level
All residents of the municipality + people who work there	People with a lower income receive more credits than people with a higher income	Weekly	Every minute	38.4%
		Weekly	Every day	41.1%
		Monthly	Every minute	40.6%
		Monthly	Every day	43.5%

8.3.5 Scenario 4: Minimize impact on travellers

The starting point of this scenario is to minimize the impact of the introduction of TPC on people who travel. This is done by basing the number of credits that someone receives on how much they travel. If credits are distributed equally among recipients, people who barely travel will receive the same amount of credits as people who travel a lot. As a result, the person who travels a lot receives few credits compared to a situation when the number of credits would be based on travel behavior. With equal distribution of credits, the system therefore has more impact on travelers than if credits are distributed based on travel behavior. The recipients of credits in this scenario are residents of the municipality and people who work there. People who work there will travel a lot in the area where credits are needed, and to also minimize the impact of TPC on them, they must also receive credits.

In this scenario, TPC has a relatively low impact on people who currently travel by car during rush hour, and at the same time gives a reward to people who now travel a lot but not during rush hour or not by car. Because of the distribution principle they get a relatively large amount of credits, which they can sell. The support levels associated with this scenario are presented in Table 8.8. Again the support for TPC decreased compared to scenario 2 in which credits were distributed equally, approximately by the same amount as in scenario 3. Distributing credits based on amount of kilometers travelled and based on income thus cause an almost equal decrease in support compared to distributing credits equally, namely around 6.5%.

A caveat to this scenario is that it is probably difficult to realize in practice, due to the distribution principle. Determining how many people travel is already a challenge. This cannot be done just once, but should be repeated regularly. However, this also provides a perverse incentive for people to travel a lot during the period when it is registered how much people travel, provided that people know when this happens, because it increases the number of credits they receive later.

Table 8.8: TPC design scenario 4

Eligible recipients of free credits	Distribution principle	Credit allocation interval	Credit price fluctuation	Support level
All residents of the municipality + people who work there	People who have traveled more km will receive more credits.	Weekly	Every minute	38.5%
		Weekly	Every day	41.4%
		Monthly	Every minute	40.8%
		Monthly	Every day	43.7%

8.4 Discussion

The TPC design with the highest support has a support level of 53.2%. This shows that there is a TPC system where a majority of people would vote in favor of the introduction compared

to maintaining the current situation. Furthermore, it has become clear that support for TPC depends on the design of TPC: the design can cause an increase in support of approximately 20%. The TPC system with the lowest support has a support level of 33.8%.

In all scenarios, four support levels were calculated based on all possibilities regarding allocation interval and price fluctuation. Choices with regard to allocation interval and price fluctuation turned out to increase or decrease support by around 5%. Support is to a greater extent determined by the recipients of credits, the distribution principle and by the the general preference for the introduction of TPC compared to maintaining the current situation of people, reflected by the ASC. Changes in the recipient of credits can cause absolute changes in support levels up to 7.8% and changes in distribution principle can cause absolute changes in support levels up to 6.64%.

Of all the scenarios, there is the least support for TPC if TPC is also used to redistribute welfare. The maximum support level for TPC is then 43.5%. The TPC design in scenario 4 where credits are distributed based on amount of kilometers travelled can also count on relatively little support, namely 43.7%. This TPC system tries to minimize the impact on travellers. It was expected that people who travel more often value this way of distributing credits significantly higher than people who travel less, but this effect was not found. Distributing credits based on amount of kilometers travelled and based on income cause an almost equal decrease in support compared to distributing credits equally if everything else remains the same, namely around 6.5%. This is an interesting finding, since it is probably considerably easier to distribute credits equally than to distribute them based on certain characteristics of recipients. So, there is more support for the TPC designs in the first two scenarios in which credits are equally distributed among recipients. If both residents and people working in the municipality receive credits, the maximum support level is 50.2%. However, if credits are only given to residents, this causes a decrease in support of 5% in absolute terms to 45.2%. If not all employees, but only those who own a car receive credits this leads to an increase in support level of approximately 3%, namely from 50.2% to 53.2%. This may however be difficult to implement, since more information needs to be collected and kept up-to-date.

9

Conclusions & Discussion

This chapter answers the research questions that were posed at the start of the study: RQ 1 in Section 9.1 and RQ 2 in Section 9.3. Furthermore, these answers are discussed. For RQ 1 this is done in a separate Section, 9.2. For RQ 2, this is done directly when giving the answers in Section 9.3. Note that the conclusions apply to residents of the transport regions Amsterdam and Utrecht and not to the entire Dutch population.

Section 9.1 answers the overarching research question about the expected support for Tradable Peak Credits (TPC) and examines what the results mean and what they add to existing knowledge. More detailed conclusions about the influence of design, socio-demographic variables, mobility habits and attitudes on support for TPC are discussed in Section 6.5. These results are not repeated here. They will however be discussed in Section 9.2.

9.1 Answer to research question 1: public support for TPC designs

The starting point of this study was the expectation that TPC has a higher public support compared to conventional road pricing such as congestion charging and kilometer charging. A lack of public support is a main barrier for the implementation of conventional road pricing policies. TPC has several characteristics that may lead to higher support and hence chance on implementation. However, since this has not been investigated before this study, the aim of this study was to discover whether TPC has in fact a higher public support or not. This knowledge is very relevant since public support is important for a government that wants to introduce a new measure to reduce congestion.

The support for the introduction of TPC was measured in two ways. First, the support for the measure in general was determined. This means that the measure was explained, but that the design variables of the measure were not specified. The support for TPC, for a congestion charge and for a kilometer charge were measured successively. 26.5% of the people in the transport regions Utrecht and Amsterdam of 18 years and older are in favor of the introduction of TPC in the municipality of Utrecht or Amsterdam, respectively. When comparing TPC, a congestion charge and a kilometer charge, TPC is the measure with the lowest support. The support for a congestion charge, 28%, is only slightly higher. The introduction of a kilometer

charge is most supported, with a support level of 35%. TPC is also the measure with the largest group of opponents, namely 51%. This percentage is slightly higher than that of a congestion charge, which is 50%. A kilometer charge has the smallest group of opponents: 45% of the people in Utrecht and Amsterdam is opposed this measure. So, a congestion charge and TPC have similar support levels. A kilometer charge is more supported.

Second, the support for specific designs of TPC systems was measured. Here, the TPC system was specified in terms of who receive credits, how credits are distributed, how often credits are distributed and how often the price of a credit fluctuates. People were asked whether they would vote in favor or against the introduction of a certain TPC system. Here higher support levels were observed than for the measure in general. Support levels lie between 33.8% and 53.2%, depending on the TPC design. This shows that there is a TPC system where a majority of people would vote in favor of the introduction compared to maintaining the current situation.

TPC thus has a lower support compared to a congestion charge and a kilometer charge when people are asked to assess them successively. In this study the support levels found for a kilometer charge were quite low compared to other studies. A recent study commissioned by de Volkskrant (I&O Research, 2019) showed that in the Netherlands 32% is in favor of the introduction of a congestion charge and 59% in favor of the introduction of a kilometer charge. Furthermore, Dogterom (2017) provides an overview of research into the acceptability of road pricing and discusses that Jaensirisak et al. (2005) conclude that the acceptability of road pricing 'without explicit mentioning of revenue use' is approximately 35% and acceptability is approximately 55% 'in cases where revenue hypothecation was specified'. This concerns different road pricing measures, among others kilometer charging and congestion charging. In this research, revenue use was shortly mentioned when asking for the support for kilometer charging and congestion charging. The support for congestion charge found in this study is only slightly lower than support found in other studies. However, the support for a kilometer charge as found in this study is considerably lower than expected based on previous studies. It is not clear why this is the case.

TPC thus does not have a higher public support than a congestion charge and a kilometer charge as was hypothesized. Introducing a TPC system is expected to be more complicated and expensive compared to introducing a congestion or kilometer charge, since a trading platform is required for TPC. Also allocating credits to the right people requires additional effort. It is therefore expected that introducing a TPC system is only considered by governments when acceptability levels are considerably higher than acceptability levels of congestion or kilometer charging. This turned out not to be the case. So, based on this research, there is currently no reason to favor TPC over a congestion charge or kilometer charge for reducing congestion based on public support.

It is however important to note here that TPC is a new and unknown measure compared to the well-known congestion charge and a kilometer charge in the Netherlands. Support levels found for TPC are quite high considering this. A fairly large group of respondents, 22.5%, indicated that they are neither for nor against TPC. This group has not yet formed their opinion about TPC and here lies potential for increasing support for TPC. As discussed by Kockelman & Kalmanje (2005) and Dogterom (2017), the support level might be increased by familiarizing people with TPC through information and experience. This study also made it clear that people are quite critical about TPC. For example, only a limited number of them expect that TPC reduces congestion, and a lot of people think that trading credits will take a lot of time and effort. By giving more information about TPC and familiarizing people with the measure, these types of attitudes might become more positive and this might increase support for TPC. Considering this, and considering the fact that the highest support level for a specific TPC design (53.2%) is almost equal to support levels for other road pricing policies, there is

sufficient reason to continue investigating TPC as an alternative to a congestion charge and a kilometer charge. Recommendations for future research are provided in Section 10.1.

9.2 Discussion of results research question 1

Two ways of measuring support for TPC
Support for the introduction of TPC was measured in two ways in this research as explained before. Support for TPC is considerably higher when people judge specific TPC designs instead of the general measure. A first possible explanation for this is that people are less supportive when it is not clear what the measure entails exactly. When respondents were asked whether they support the general measure, a number of important aspects of the measure was not specified, namely who receives credits, how credits are distributed, how often they are distributed and how often the credit price fluctuates. These are aspects that largely influence the impact that the measure has on them and it is expected that this therefore also largely influences their opinion about the measure. By being specific about the design of these aspects, people know more clearly which system to assess. It is expected that if people are asked to assess a general measure that is not very concrete, then as a precaution, they will be more negative about the measure since the measure can still take shape in a way that is not desired. An alternative explanation is that the reference point influences the support levels. When respondents were provided with the specific TPC designs, support was based on their choice between the introduction of that specific TPC design and maintaining the current situation. When respondents were asked to what extent they supported TPC in general, they were also asked to what extent they supported a congestion charge and a kilometer charge. It is possible that this change in reference point makes people more negative about TPC.

The variables that influence support for TPC
In road pricing literature there has already been a lot of research into which variables influence the acceptability of road pricing measures. The findings of this study support the conclusion of Dogterom (2017) that socio-demographic variables have limited influence on the acceptability of road pricing measures and that attitudinal variables are much more predictive for acceptability. According to the literature review performed by Dogterom, 'Problem perception, fairness, infringement on freedom, expected effectiveness and expected personal outcome' are important for the acceptability of a measure. This study supports that attitudes regarding fairness, infringement on freedom and expected effectiveness influence the support of TPC. However, problem perception and expected personal outcome did not significantly influence this support. In contrast to the study of Dogterom (2017), the expectation of how effective the measure reduces the impact of traffic on the environment did have a significant impact on support for the measure. This is a striking outcome, since in the introduction of TPC to respondents the measure was discussed purely as measure to reduce congestion and the influence on the environment was not discussed. Furthermore, an interesting outcome is that whether people trust that TPC is feasible and that the government is able to implement and maintain the system is important for the support of TPC. Also whether people expect the trading of credits to be fun is very important for the support of TPC. This is interesting, since the importance of this attitude was not highlighted in the current literature on tradable credits and road pricing.

The found support levels for TPC, congestion charging and kilometer charging
Previously, the support for TPC has never been investigated quantatively among a large sample. It is therefore not possible to compare the support levels as predicted in this study to similar studies. There has been a focus group study that explored public perceptions of tradable credits for congestion management (Krabbenborg et al., 2019). 36 people took place in the

focus groups, of which seven (19.4%) were positive towards TPC during the discussion. Eight people (22%) indicated in a short survey that followed the discussion that they agreed with the statement 'I consider tradable peak credits an acceptable system'. It was not asked whether people are in favor of introducing TPC, as was asked in this study. However, if we assume that that people who agreed with the aforementioned statement are also in favor of introducing TPC, then about 22.2% of people would be in favor of introducing TPC. This is slightly less than was found in this study, namely 26.5%.

Furthremore, there are studies that examined the acceptability of systems that are comparable to TPC. Dogterom (2017) investigated the acceptability of a kilometer-based Tradeable Driving Credits (TDC) system among Dutch car users, who experienced the system in an online experiment. TDC are required for every trip, while TPC are only required for trips during peak hours. Dogterom asked respondents: How acceptable is Tradable Driving Credits overall to you? Dogterom found an acceptability of 22% in the Netherlands. In this study, support for TPC was measured with a similar question, and this yielded a support level of 26.5%. The support for TPC is thus slightly higher than the support for TDC. When studying the support for specific TPC designs, the support levels are between 33.8% and 53.2% and can therefore be a considerably higher than the support for TDC. However, it might be the case the support for TDC is also higher if more concrete designs of the system would have been studied.

As discussed in Section 9.1, the support levels for a kilometer charge as found in this study are considerably lower than support levels found in other studies. It is not clear why this is the case. A possibility is that the sample of this research was more critical than for example the sample of the Volkskrant (I&O Research, 2019). If this is the case, the sample might also think differently about TPC than another sample. It is however not clear if this sample would support TPC more of less if they are more critical towards a kilometer charge.

Preferences regarding TPC design

In Chapter 4, literature on personal tradable credit systems was used to identify design variables of a TPC system. Preferences regarding design variables that were identified in this research will now be discussed in relation to the existing literature on personal tradable credits.

In existing literature, it is mainly suggested that the residents of the area where TPC is introduced, or subgroups of these residents such as car owners or licensed drivers should be the recipients of credits. This research shows that if you introduce TPC in a certain area, it is very important for the support of TPC that people who do not live there but do work receive credits. Furthermore, Raux (2007) expects that the acceptability of a personal tradable credits system is higher when not only car owners, but all residents receive credits. According to this research, the opposite is the case.

Bristow et al. (2010) investigated personal carbon trading. They found that there was a preference to support groups of people in greater need. In this study something similar has been investigated by studying whether there is support for a distribution principle where people with a lower income receive more credits than people with a higher income. However, this turned out to be the least supported of all the distribution principles examined. An important difference between the two studies, however, is that at in the study of Bristow et al. the people in greater need received extra credits, but that this did not affect the number of credits that the other people received. So this would imply that people do support aid for the people in greater need, but not if it disadvantages themselves.

9.3 Answer to research question 2 & discussion: the effect of medium and information of the introduction in stated choice experiments

2.1 What are the effects of the type of information included on preferences and attitudes?

In the stated choice experiment, half of the respondents received only an explanation of how TPC works, the other half received this same explanation and in addition received information on the underlying problem that a TPC systems should reduce. We were interested in finding out to what extent this choice on what information to include in the introduction of a stated choice experiment influenced the results of the experiment.

People who not only read about how the TPC systems works, but who also read about the negative consequences of traffic jams valued TPC alternatives higher than people who only read about how the TPC systems works. This was expected, since it was hypothesized that people who have the problem and the extent of the problem in mind are more positive towards a solution to the problem. The difference was however not significant and can therefore not be generalized to the population.

People who read about the negative consequences of traffic jams did not differ from people who were not informed about this in the extent to which they expect TPC to have positive outcomes for them, and in the extent to which they support the introduction of TPC. However, they did perceive traffic jams as more problematic. So priming information can cause respondents to respond differently to a statement related to that information than respondents where the information was not primed. This means that what information is included in a survey can influence the results of the survey. Of the tested attitudes, adding information did however only influence the attitude that was directly linked to the information that was added. In this case, adding information about the negative consequences of traffic jams only influenced the attitude how problematic traffic jams are. It did not influence attitudes that are less directly connected, such as support for a measure to reduce traffic jams. Furthermore, the data from this research shows that a large part of the respondents did not remember this at the end of the survey. The added information only influenced people who consciously read the information in a way that they remember this at the end of the survey. Lastly, it was only tested whether added information influenced an attitude when the attitude is measured quickly after reading the information. It has therefore not been investigated whether the attitude changed over the long term. Even if the attitude does not change in the long term, it is an interesting insight if it does happen in the short term. When researchers unconsciously influence an attitude that they measure by adding certain information, their data on attitudes does not match the attitudes on a longer term.

2.2 What are the effects of different communication mediums, specifically plain text and an animation video with a voice-over on preferences, attitudes and drop out?

In the stated choice experiment, half of the respondents received the introduction to TPC via text and the other half via a video with subtitles and a voice-over. The aim was to find out to what extent this communication medium of introduction in a stated choice experiment influenced the results of the experiment.

People who received the introduction of TPC via a video valued TPC slightly higher than people who received that same introduction in written text. However, this effect was not significant.

Respondents were asked to indicate on a scale of 1 (fully disagree) to 5 (fully agree) whether

they thought the explanation of TPC was clear. Respondents who received the introduction to TPC in a video found the explanation slightly clearer (average of 4.09) than the respondents who received the introduction in text (average of 3.89). This difference is relatively small, but statistically significant. However, this does not mean that they think TPC is less complicated than the people who read about it. Both groups found TPC equally complicated.

The drop out among respondents who received the introduction via a video was exactly the same as the drop out among respondents who received this same introduction in written text. However, there was a clear difference in the moment of dropping out between these two groups. Of the people dropping out before even starting to read or view the introduction to TPC, the vast majority had the video. It is expected that this is caused by practical problems, such as the data costs linked to watching the video. When looking at the people dropping out after reading or viewing (part of) the introduction, it is interesting to note that the opposite occurs: here the vast majority had the written text. So, once people have started the introduction, they complete it more often and continue with the survey more often if they received the introduction via a video instead of written text. Once people have started watching the video, this medium causes less dropout than text does. If practical barriers to watching a video can be avoided, using a video might therefore be more suitable than using a text to limit drop out.

2. What are the effects of the medium and content of the introduction in a stated choice experiments on preferences, attitudes and drop out?

In this study, variations in the introduction did not have a significant influence on the choices made by respondents in the stated choice experiment. There was, however, a significant influence on an attitude of respondents that was directly linked to the content variation that had been introduced in the introduction. This confirms that choices regarding what you discuss in the introduction may influence the results of the study. Specifically, this study made clear that if you measure an attitude, this measurement can be influenced by discussing information about that attitude in the introduction or not. It is important that researchers who use these types of research methods are aware of this. Furthermore, people who received the introduction to TPC via a video found the explanation slightly clearer than people who received it in written text. Furthermore, the drop out was not greater when receiving a video instead of text, or the other way around. However, people receiving a video mostly dropped out before even starting the video. When they did watch the video, the drop out in the remainder of the survey was lower compared to people who received the introduction via written text.

10

Reflection & Recommendations

This chapter first of all reflects on possible limitations of this study and provides recommendations for future research (Section 10.1). Subsequently, recommendations are made to policy makers (Section 10.2) and researchers (Sections 10.3). Finally, there is a reflection on the contribution of this research on scientific and societal level (Section 10.4).

10.1 Reflection on possible limitations & recommendations for future research

Several possible limitations of this research were identified and will be discussed here. These limitations are important to acknowledge, since they can influence how the results of the research should be interpreted and how they can be used.

10.1.1 Research question 1

Limitations linked to the data collection method

- Attitudes were measured with a limited amount of statements.
  In this study, a number of attitudes was measured with only one statement. This was done to limit the survey length. It is however better to use more statements per attitude, since it can then be assessed whether the statements actually measure the same attitude.
- High drop out and possible self-selection.
  The sample of this study might have been influenced by self-selection. Several types can be distinguished. First of all, only people who are voluntarily part of the panel of CG research could become part of the sample. This can lead, for example, to people who like to express their opinion being overrepresented in the sample. Secondly, members of the panel could decide themselves whether they wanted to participate in the study. The drop out rate of this of this study was quite high (42.3%). This drop out may have resulted in people with a stronger opinion about TPC or road pricing in general (both negative and positive) being overrepresented in the sample. This may also have caused an overrepresentation in the sample of people who have relatively much free time, for example because they are retired. Lastly, this may have resulted in people who found

TPC complex dropping out more and therefore an overrepresentation of people who think they understand TPC well.

- Influence of reward for respondents.
  Respondents were part of a panel and could earn points by completing the survey (see Section 5.6). This may have led to people completing the survey quickly and perhaps not always seriously, because they mainly wanted to receive the reward. This behavior has been taken into account by omitting data from people who have completed the survey unrealistically fast (see Appendix J). But this probably did not solve the entire problem, since it is still visible in the data that some respondents only spend a very short time on the page with the introduction of TPC. As a result, there is doubt as to whether they have received all the information on TPC properly and therefore really knew what TPC entailed. As a result, indicated preferences with regard to TPC may deviate from preferences that respondents would have if they had read the introduction of TPC correctly.

- Attitudes were not used to predict support levels.
  In Chapter 6 a ML model was estimated and this showed that several attitudes towards TPC significantly influence the choice for or against TPC and that including these attitudinal variables increases the model fit. However, the support levels for TPC were predicted in Chapter 8 using a model without these attitudinal variables.

  Recommendation for future research: Use extended ML model to evaluate scenarios on attitudes towards TPC.
  It would be interesting to also use the model with the attitudinal variables to predict support levels for TPC under various scenarios regarding the attitudes towards TPC in the population. It is unknown how attitudes towards TPC will develop, but it is insightful to draw up scenarios and to study to what extent the support for TPC can vary between these scenarios.

- Attitudinal variables were included in a ML model.
  As discussed by Kim et al. (2014) the way in which attitudinal variables were included in the ML model in this study has several drawbacks.

  Recommendation for future research: Develop a hybrid choice model.
  This study has shown that several attitudes regarding TPC are important determinants for the support of TPC. Other road pricing literature also shows that attitudinal variables have great predictive power for the support for road pricing measures (Dogterom, 2017). In this study, attitudinal variables were incorporated in a MNL and a ML model. However, using hybrid choice models are a better choice when there is a desire to include attitudinal variables. Attitudes are then included as latent variables that are functions of the statements that were used as indicators of that attitude (Kim et al., 2014). The disadvantage of including the statements used to measure attitudes directly in the utility function, as is done in this study, is that this 'ignores the fact that latent variables contain measurement error' (Kim et al., 2014, p.22). The disadvantage of including multiple statements as one latent variable based on factor analysis, as is also done in this study, is that 'the estimated latent variables can be inefficient because the choice indicators (i.e. the actual choice behaviors of respondents) are not considered when estimating the latent variables' (Kim et al., 2014, p. 22). It is therefore recommended to develop a hybrid choice model. Figure 10.1 shows a conceptual outline of this model. A hybrid choice model can provide a better understanding of the choice process of people regarding the choice for or against the introduction of TPC (Kim et al., 2014).

  It must be noted that there is a debate going on about the practical applicability of

hybrid choice models that include attitudes and perceptions as latent variables. It is important to be aware of this discussion. Chorus & Kroesen (2014) discuss two problems regarding deriving policy implications from hybrid choice models. The first is that the latent variables are usually endogenous to the choice behavior. Specific attitudes, which are very close to behavior, do have a strong correlation with that behavior, but specific attitudes are also strongly influenced by the behavior. Therefore, specific attitudes have a low predictive power for behavior according to them (Chorus & Kroesen, 2018). The second is that latent variables are often measured at one point in time. Due to this, it is not possible to evaluate how a change in a latent variable for one individual influences the choice behavior of this individual. So no within-person comparison is possible, only between-person comparison. They argue that due to these issues, hybrid choice models do not support the derivation of policies that aim to change a latent variable, so for example an attitude, in order to change choice behavior. It is therefore recommended to be cautious in using the hybrid choice model to make recommendations that focus on influencing attitudes (latent variables) in order to increase support for TPC. There is limited evidence that these types of recommendations are effective (Chorus & Kroesen, 2014). This debate is ongoing and the implications for the use of hybrid choice models are not yet clear. It is therefore recommended to follow this discussion and reflect upon its implications.

Concluding, estimating a hybrid choice model is a way to improve the research that was executed. A hybrid choice model is more suitable for including attitudes than a MNL and a ML model. This hybrid choice model can then be used to predict support levels for TPC. By comparing these support levels to the support levels found in this study with the ML model, insight is gained into the extent to which the inclusion of attitudes in the model influences the support levels found. Since it is unknown how the attitudes in the population will develop, it would be interesting to draw up various scenarios on the attitudes in the population. For each scenario, the support for TPC can be computed. Furthermore, it is important to be careful with deriving policy implications that focus on influencing attitudes from hybrid choice models.

Limitations linked to the data interpretation

- The influence of the credit price and the effectiveness of the TPC system are unknown.
  It is unknown what the credit price range would be and to what extent congestion would be reduced if TPC is introduced. It was however considered important to communicate this information to respondents when explaining TPC to them in the survey. Therefore an educated guess had to be made. This has been done as well as possible by consulting several researchers in this field, but it remains only an estimate. The expectation is that these numbers can influence the support of respondents for TPC. However, it is unknown how large that influence is. It is therefore also unknown to what extent support levels for TPC change if the price range of a credit and the percentage of congestion reduction by TPC would change.

- Hypothetical bias may play a role.
  It was predicted for several TPC designs how many people would vote for the introduction of that TPC system and thus support that TPC design. Hypothetical bias could however play a role in this research. Respondents were confronted with hypothetical situation in which they needed to make a choice. It is unclear whether respondents act different in real life than in this hypothetical situation. If respondents do act different in a hypothetical situation, it is unknown to what extent the predicted support levels for TPC would be higher or lower in real life.

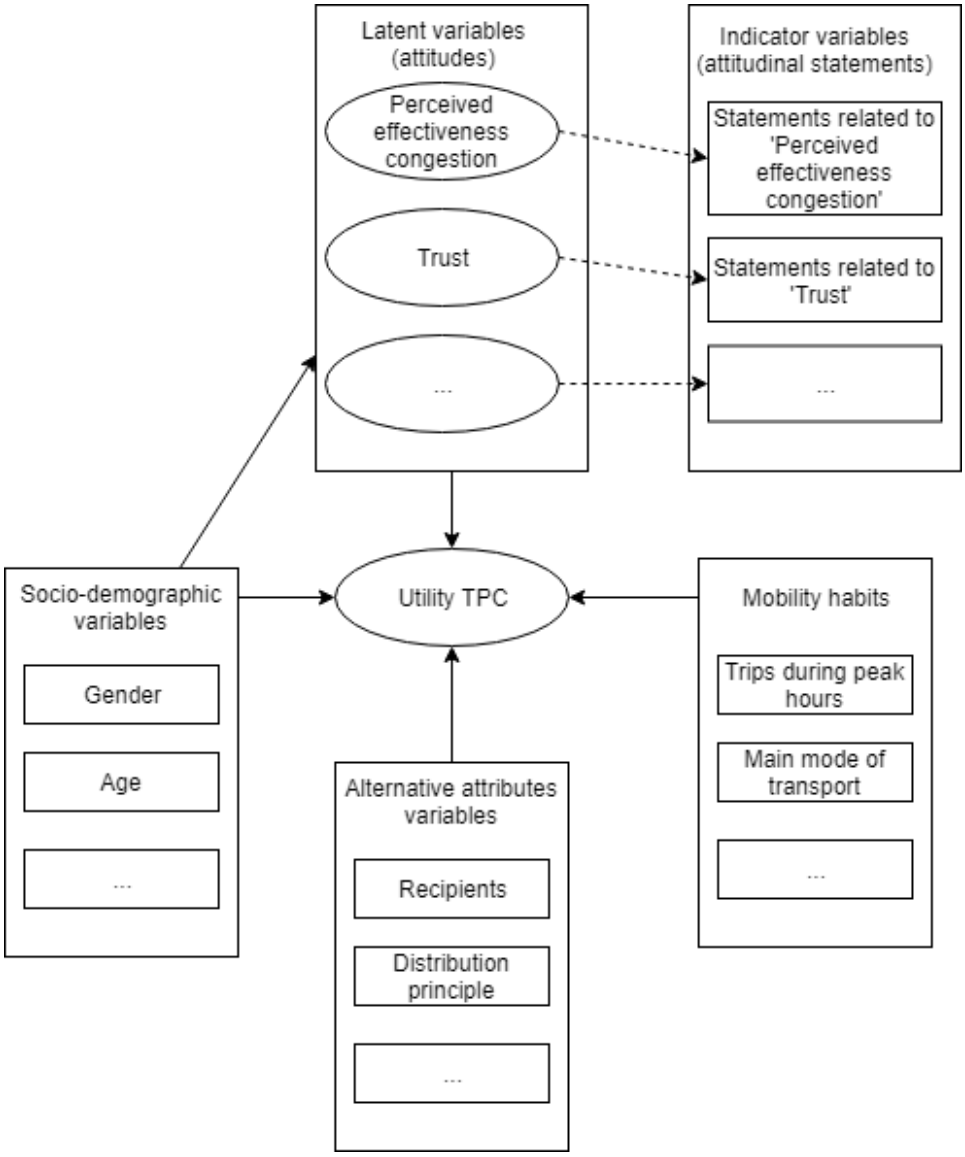


Figure 10.1: Conceptual outline of the hybrid choice model that is recommended

- The unrepresentativeness of the sample.
  The sample in this study was unrepresentative for the population in terms of gender, age and educational level. Whether it is representative for income is unknown. However, as substantiated in Section 8.1 the support predictions based on sample are expected to be good predictors for support in the population. It is however unknown whether the attitudes regarding TPC in the sample are representative for the attitudes in the population. As discussed in before, self-selection may have played a role and this may have resulted in people with strong opinions about TPC (positive or negative) being over-represented in sample.

  Recommendation for future research: Repeat this stated choice experiment under a new sample.
  As discussed in Section 9.2, the support levels for a kilometer charge as found in this study are considerably lower than support levels found in other studies. A possibility is that the sample of this research was more critical than for example the sample of the Volkskrant (I&O Research, 2019). If this is the case, the sample might also think

differently about TPC than another sample. It is however not clear if this sample would support TPC more of less if they are more critical towards a kilometer charge. It would therefore be interesting to repeat the stated choice experiment of this research among another sample to see whether this leads to different support levels for TPC.

- The reasoning of respondents behind choices is unknown.
  It is unknown what assumptions respondents made when making the choices and answering the questions, while these assumptions might influence these choices and answers. This is generally the case in questionnaires and stated choice experiments, but it might pose a greater problem in this study since TPC is a new and complex measure. This can increase the chance of wrong assumptions occuring. The comments that respondents made at the end of the survey showed that some respondents misunderstood an aspect of TPC. Such wrong assumptions might have influenced their choices and answers. In a study where there is face-to-face contact with respondents, for example a focus group, it may be easier to clear up misconceptions about TPC. However, the advantage of a digital stated choice study is that it is much easier to collect data from many respondents.

  Furthermore preferences regarding design variables of TPC were revealed in this study. However, it is unknown what the reasoning is behind people preferring a certain design element over another design element. It is possible to speculate on this, but it is impossible to draw conclusions on this based on this research. This would require additional qualitative research.

  Recommendation for future research: Perform additional qualitative research.
  Qualitative research can be performed to learn more about the reasoning of respondents behind the preferences discovered in this research. Focus groups or interviews can for example be used to discuss the different design variables and to find out why people prefer certain design choices over others. Of the four design variables of TPC that were included in this study, only a few options were investigated for each variable. For example, four principles for distributing credits have been investigated, while there are of course many more options. By getting qualitative insights into the reasoning behind these preferences, it might be possible to further adapt the design of the TPC system to the preferences of the public.

Additional recommendations

- Investigate the required credit allocation interval and credit price fluctuation.
  Investigate what credit allocation interval is necessary to achieve the desired reduction in congestion, and what price fluctuation frequency is necessary to achieve efficient allocation of credits among participants. This study provided insight in what the preference of the public is regarding these design variables of TPC, however, it is unknown whether these preferences are compatible with the requirement that the TPC system should be effective in reducing congestion and should lead to optimal credit prices.
- Investigate whether there is a difference between people living inside and outside the municipality where TPC would be introduced with respect to the utility they derive from TPC.
  The population of this study consisted of residents of the transport regions Amsterdam and Utrecht. However, the scenario in the stated choice experiment was that TPC would be introduced in the municipality of Amsterdam and Utrecht. It would be interesting to investigate whether people living inside and outside the municipality differ in their support for the introduction of TPC. This can be investigated by creating a variable that

indicates whether someone lives in the municipality or not and including this in the choice models.

- Measure the support for the introduction of TPC of people who have experienced the system.
  It is hypothesized that the support for TPC could be increased by familiarizing people with TPC. Future research could investigate whether this is the case. Use a mock-up or a simulation game to let people experience the use of peak credits and credit trading for some time. After this, measure whether people support the introduction of TPC.

10.1.2 Research question 2

In this research, a start has been made on investigating the influence of the introduction of a stated choice experiment on its outcomes. Only two variations on the introduction have been tested. However, this research showed that the introduction can influence the results, which makes it interesting and useful to investigate this further. First of all, it is recommended to test the variations made in the introductions in this study in more studies, to see if comparable results are found. Furthermore, it is recommended to identify more variations in introductions and to determine the influence of these variations. It could for example be tested whether the amount of details included about a new policy measure influences results. However, many more variations can be devised. Lastly, it is recommended to study whether different communication mediums are preferred by different groups of people. This way, researchers can let the choice of their medium be guided by the target group of their research.

10.2 Recommendations for policy makers

TPC is shown to be a promising alternative to other road pricing policies that are considered by policy makers. Therefore, based on the results of RQ 1, recommendations are now being made about the design of a TPC system and about the process of introducing a TPC system.

Design of TPC system

- Equal distribution of credits among recipients seems the best way to distribute credits. This distribution principle has by far the most support from the public. Moreover it is considerably easier to distribute credits equally than to distribute them based on certain characteristics of recipients, since then information regarding that characteristics is required about each recipient. By distributing equally over all recipients, no new information needs to be collected and kept up-to-date. This makes the system both relatively easy to set up and relatively cheap compared to applying other credit distribution principles. Also for privacy reasons, this principle is expected to be the most feasible and the least intrusive.
- Do not use TPC as a tool to redistribute welfare. It was investigated whether there is support to give people with a higher income fewer credits than people with a lower income. It turned out that the support for TPC can decrease considerably when applying this method of distributing credits.
- Give not only credits to residents of the area where TPC is introduced, but also to people who work but not live in that area. The support for TPC is highest if only those employees who own a car receive credits, instead of all employees. It is interesting to investigate if this can be realized by cooperating with employers within the municipality, so that

credits can be provided to them which can in turn be used by their employees that need to commute.

- Have investigated what credit allocation interval is necessary to achieve the desired reduction in congestion. If monthly credit distribution has the same effects on congestion as weekly distribution, distribute credits every month.
- Have investigated what price fluctuation frequency is necessary to achieve efficient allocation of credits among participants. If letting the credit price fluctuate only once a day instead of more often can achieve this, then let the credit price only fluctuate once a day.
- When developing the trading platform, pay attention not only to functionality, but especially to how credit trading can be made fun for people. Investigate what mechanisms can be used to increase the pleasure of trading. Involve future users in the entire development process. Make for example different prototypes and conduct user studies to see how different groups of users react to them. User-centered design might be used as an approach in developing the trading platform.

Process around introducing a TPC system

- Let people experience credit trading before TPC would actually be introduced, for example with a mock-up or via a simulation game. In this way, future users can get a better idea of what the system would entail and they can already discover whether they like trading credits.
- If a policy maker in a certain region considers introducing TPC in a certain region, but first wants to gauge how much support there is, be specific towards people about the TPC design that you are considering to introduce. This research raised the expectation that support levels can be considerably higher for specific TPC designs than for the measure in general.
- When communicating about TPC, certainly mention the beneficial effects that this measure can have on emissions from transport. The expectation of people that TPC can reduce the impact of cars on the environment can increase support for TPC. At present, people expect this only to a limited extent. The same applies to the expectation that TPC can reduce congestion. A note on this recommendation is that there is criticism on making recommendations to influence attitudes in order to influence choice behavior. This criticism is expressed by Chorus & Kroesen (2014).
- Take advantage of the current focus on the environment. A large package of measures is now being taken in the climate agreement to reduce CO2 emissions. This offers an interesting window of opportunity: the introduction of a measure such as TPC, or taking steps towards this, is currently more feasible due to this context.

10.3 Recommendations for researchers using stated choice experiments

Based on the insights gained with RQ 2, the following recommendations are made to researchers who make use of stated choice experiments.

- Be transparent about the introduction that was used in the stated choice experiment, by also publishing this. This study showed that the introduction can influence the results of the study. It is therefore important to show what this introduction entailed.

- When choosing your medium, think carefully about your target group. Consider which practical barriers can play a role for your target group and whether they can be overcome. When using a video, there might be barriers such as the costs of data required to watch the video. If such barriers are expected and cannot be removed, it is recommended not to use video, as this can cause a high dropout. If those barriers are not there, or if they can be removed, a video is an interesting alternative to written text. This study showed that if people start watching the video, a video causes less drop out than written text. Also, the introduction via video was perceived as more clear than the same introduction via written text.

- Keep the introduction to the subject of the stated choice experiment short. In this study, the introduction was quite long and it is expected that is partly caused the high drop out.

- Be aware of the fact that everything that is included in the introduction to the subject of the stated choice experiment may influence the choices of respondents. Only include information that respondents would have if they faced the same choice in real life, to mimic real life conditions as good as possible and to avoid hypothetical bias.

10.4 Reflection on contribution of the research

10.4.1 Reflection on scientific contribution

So far, research on systems with tradable driving credits for mobility management has mainly been conducted into behavioral effects and effects on the road network of implementing such a system. This research extends the knowledge about these systems with empirical research into the public support of such a system and factors that influence this support. Only Dogterom has previously done this for a slightly different system, namely a system with credits representing a kilometer travelled. This study is however the first to provide knowledge about support for a system with peak credits. In addition, this study investigated support depending on the design of the system. Dogterom has not done this, but did mention it as an important knowledge gap to investigate. Furthermore, this research has created a clear overview of the design variables of a TPC system, and has exposed the preferences of the public with regard to a number of these design variables. Also two attitudes that are important for the choice for or against TPC that were not identified in existing literature have been identified: trusting that TPC is feasible and that the government is able to implement and maintain the system and expecting the trading of credits to be fun. Furthermore, this study also showed that support levels for a specific design of a measure extracted with a stated choice experiment can vary greatly from support levels for a general measure that is measured with a simple rating question. Being specific about the design of a measure may therefore lead to completely different conclusions about the support for a measure.

This research furthermore took a first step in investigating the extent to which variations in the introduction of a stated choice experiment can influence the results of the experiment. This research has shown that there can be such influence. This provides grounds for further investigation. Also interesting effects of communication mediums on respondents dropping out of a survey were shown.

10.4.2 Reflection on societal contribution

The current government has announced to start doing experiments with a TPC system. For them, this research already provides first insights into the acceptance of such a measure. This is very important knowledge, since support to date has often been the stumbling block for the introduction of road pricing measures. Furthermore, this research already offers them guidelines on how to design a TPC system.

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References

Ardiç, O. (2015). Road pricing policy process: The interplay between policy actors, the media and public.

Aziz, H. A., Ukkusuri, S. V., & Romero, J. (2015). Understanding short-term travel behavior under personal mobility credit allowance scheme using experimental economics. *Transportation Research Part D: Transport and Environment, 36,* 121-137.

Baggett, P. (1984). Role of temporal overlap of visual and auditory material in forming dual media associations. *Journal of Educational Psychology, 76(3)*, 408.

Bao. Y., Gao, Z., Xu, M. & Yang, H. (2014) Tradable credit scheme for mobility management considering travelers' loss aversion. *Transportation Research Part E 68,* 138- 154.

Ben-Akiva, M., McFadden, D., & Train, K. (2018). Foundations of stated preference elicitation: Consumer behavior and choice-based conjoint analysis. *Foundations and Trends® in Econometrics, 10(1-2)*, 1-144.

Bierlaire, M. (2018). *PandasBiogeme: a short introduction.* Technical Report TRANSP-OR 181219, Transport and Mobility Laboratory, Ecole Polytechnique Fédérale de Lausanne.

Bolderdijk, J. W., Steg, L., & Postmes, T. (2013). Fostering support for work floor energy conservation policies: Accounting for privacy concerns. *Journal of Organizational Behavior, 34(2)*, 195-210.

Brands, D., Verhoef, E. T., Knockaert, J., & Koster, P. (2019). Tradable permits to manage urban mobility: market design and experimental implementation.

Bristow, A. L., Wardman, M., Zanni, A. M., & Chintakayala, P. K. (2010). Public acceptability of personal carbon trading and carbon tax. *Ecological Economics, 69(9)*, 1824-1837.

Centraal Bureau voor de Statistiek (CBS). (2012). *In ochtendspits 2,4 miljoen mensen achter het stuur.* Retrieved from https://www.cbs.nl/nl-nl/nieuws/2012/50/in-ochtendspits-2-4-miljoen-mensen-achter-het-stuur

Centraal Planbureau voor de Statistiek (CPB). (2016). *Kansrijk Mobiliteitsbeleid.* Retrieved from https://www.cpb.nl/sites/default/files/omnidownload/CPB-PBL-Boek-23-Kansrijk-mobiliteitsbeleid_0.pdf

Choi, H. J., & Johnson, S. D. (2005). The effect of context-based video instruction on learning and motivation in online courses. *The American Journal of Distance Education, 19(4)*, 215-227.

Choice Metrics. (2018). *Ngene 1.2. USER MANUAL & REFERENCE GUIDE. The Cutting Edge in Experimental Design.* Retrieved from http://www.choice-metrics.com/ Ngene-Manual120.pdf

Chorus, C. G., & Kroesen, M. (2014). On the (im-) possibility of deriving transport policy implications from hybrid choice models. *Transport Policy, 36*, 217-222.

Coase, R. H. (1960). The problem of social cost. In *Classic papers in natural resource economics* (pp. 87-137). Palgrave Macmillan, London.

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. *Sage publications.* Retrieved from https://www.sagepub.com/sites/default/files/upm-binaries/55588_Chapter_1_Sample_Creswell_Research_Design_4e.pdf

Daamen, D. D., Terwel, B. W., Ter Mors, E., Reiner, D. M., Schumann, D., Anghel, S., ... & Dudu, A. (2011). Scrutinizing the impact of CCS communication on opinion quality: focus group discussions versus Information-Choice Questionnaires: results from experimental research in six countries. *Energy Procedia, 4,* 6182-6187.

Defra. (2008). Synthesis report on the findings from Defra's pre-feasibility study into personal carbon trading. April 2008. Retrieved from https://www.flemingpolicycentre.org.uk/ Synthesis.pdf

Dieplinger, M., & Fürst, E. (2014). The acceptability of road pricing: Evidence from two studies in Vienna and four other European cities. *Transport Policy, 36*, 10-18.

Dogterom, N., Ettema, D., & Dijst, M. (2018). Behavioural effects of a tradable driving credit scheme: Results of an online stated adaptation experiment in the Netherlands. *Transportation Research Part A: Policy and Practice, 107*, 52-64.

Dogterom, N. J. (2017). *Tradable Driving Credits: car users' responses towards an innovative pricing measure in the Netherlands and China* (Doctoral dissertation, Utrecht University).

Dujardin, A. (2017, August 30). Wat als je stadsbewoners een verzilverbaar 'parkeerrecht' geeft? *Trouw.* Retrieved from https://www.trouw.nl/home/wat-als-je-stadsbewoners-een-verzilverbaar-parkeerrecht-geeft- a0ff0d32/

Dutch Emissions Autority. (n.d.). *Algemeen ETS.* Retrieved from https://www.emissieautoriteit.nl/onderwerpen/algemeen-ets

Eisinga, R., Te Grotenhuis, M., & Pelzer, B. (2013). The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown?. *International journal of public health, 58*(4), 637-642.

Eriksson, L., Garvill, J., & Nordlund, A. M. (2006). Acceptability of travel demand management measures: The importance of problem awareness, personal norm, freedom, and fairness. *Journal of environmental psychology, 26*(1), 15-26.

Fan, W., & Jiang, X. (2013). Tradable mobility permits in roadway capacity allocation: Review and appraisal. *Transport Policy, 30*, 132-142.

Fawcett, T. (2010). Personal carbon trading: A policy ahead of its time?. *Energy policy, 38*(11), 6868-6876.

Frey, B. S. (2003). Why are efficient transport policy instruments so seldom used?. In *Acceptability of transport pricing strategies*(pp. 63-75). Pergamon Press.

Fujii, S., Gärling, T., Jakobsson, C., & Jou, R. C. (2004). A cross-country study of fairness and infringement on freedom as determinants of car owners' acceptance of road pricing. *Transportation, 31*(3), 285-295.

Gao, G., & Sun, H. (2014). Internalizing Congestion and Emissions Externality on Road Networks with Tradable Credits. *Procedia-Social and Behavioral Sciences, 138*, 214-222.

Gemeente Amsterdam. (2018). Amsterdam in cijfers 2018. Onderzoek, Informatie, Statistiek. Retrieved from https://www.ois.amsterdam.nl/downloads/pdf/2018%20jaarboek%20 amsterdam%20in%20cijfers.pdf

Gendall, P., Hoek, J., Pope, T., & Young, K. (2006). Message framing effects on price discounting. *Journal of Product & Brand Management, 15*(7), 458-465.

Gevrek, Z. E., & Uyduranoglu, A. (2015). Public preferences for carbon tax attributes. *Ecological Economics, 118,* 186-197.

Goddard, H. C. (1997). Using tradeable permits to achieve sustainability in the world's large cities: policy design issues and efficiency conditions for controlling vehicle emissions, congestion and urban decentralization with an application to Mexico City. *Environmental and Resource Economics, 10*(1), 63-99.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2013). *Multivariate data analysis: Pearson new international edition.* Pearson Higher Ed.

Hamilton, C. J., Eliasson, J., Brundell-Freij, K., Raux, C., Souche, S., Kiiskilää, K., & Tervonen, J. (2014). Determinants of congestion pricing acceptability. *Stockholm: Centre for Transport Studies, CTS Working Paper,* 2014, 11.

Harrington, W., Krupnick, A. J., & Alberini, A. (2001). Overcoming public aversion to congestion pricing. *Transportation Research Part A: Policy and Practice, 35*(2), 87-105.

Hensher, D. A. (2006). How do respondents process stated choice experiments? Attribute consideration under varying information load. *Journal of applied econometrics, 21*(6), 861-878.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). *Applied choice analysis: a primer.* Cambridge University Press.

Hoehn, J. P., Lupi, F., & Kaplowitz, M. D. (2010). Stated choice experiments with complex ecosystem changes: the effect of information formats on estimated variances and choice parameters. *Journal of Agricultural and Resource Economics*, 568-590.

Howard, K., & Salkeld, G. (2009). Does attribute framing in discrete choice experiments influence willingness to pay? Results from a discrete choice experiment in screening for colorectal cancer. *Value in Health, 12*(2), 354-363.

I&O Research. (2019). *Kilometerbeprijzing? Ja, maar onder voorwaarden.*

Jaensirisak, S., Wardman, M., & May, A. D. (2005). Explaining variations in public acceptability of road pricing schemes. *Journal of Transport Economics and Policy (JTEP), 39*(2), 127-154.

Jakobsson, C., Fujii, S., & Gärling, T. (2000). Determinants of private car users' acceptance of road pricing. *Transport policy, 7*(2), 153-158.

Jansen, S., Boumeester, H., Coolen, H., Goetgeluk, R., & Molin, E. (2009). The impact of including images in a conjoint measurement task: evidence from two small-scale studies. *Journal of housing and the built environment, 24*(3), 271-297.

Kennisinstituut voor Mobiliteitsbeleid (KiM). (2018, October). *Kerncijfers mobiliteit 2018.* Den Haag: Ministerie van Infrastructuur en Waterstaat. Retrieved from https://www.rijksoverheid.nl/ministeries/ ministerie-van-infrastructuur-en-waterstaat/documenten/rapporten/2018/10/29/bijlage-1-kim-kerncijfers-mobiliteit-2018

Kim, J., Rasouli, S., & Timmermans, H. (2014). Hybrid choice models: principles and recent progress incorporating social influence and nonlinear utility functions. *Procedia Environmental Sciences, 22*, 20-34.

Kockelman, K. M., & Kalmanje, S. (2005). Credit-based congestion pricing: a policy proposal and the public's response. *Transportation Research Part A: Policy and Practice, 39*(7-9), 671-690.

Koppelman, F. S., & Bhat, C. (2006). A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models. Retrieved from http://www.ce.utexas.edu/prof/bhat/COURSES/LM_Draft_060131Final-060630.pdf

Krabbenborg, L., Mouter, N., Molin, E., Annema, J.A. & van Wee, B. (2019) Exploring public perceptions of tradable credits for congestion management: a focus group study. Manuscript in preparation.

Kragt, M. E., & Bennett, J. W. (2012). Attribute framing in choice experiments: how do attribute level descriptions affect value estimates?. *Environmental and Resource Economics, 51*(1), 43-59.

Kroesen, M., & Chorus, C. (2018). The role of general and specific attitudes in predicting travel behavior–A fatal dilemma?. *Travel behaviour and society, 10*, 33-41.

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications.* Cambridge university press.

Luchini, S., & Watson, V. (2013). Uncertainty and framing in a valuation task. *Journal of Economic Psychology, 39*, 204-214.

McFadden, D. (2017). Stated preference methods and their applicability to environmental use and non-use valuations. *Contingent Valuation of Environmental Goods: A Comprehensive Critique,* 153.

McFadden, D. (1974). "Conditional Logit Analysis of Qualitative Choice Behavior." In P. Zarembka (ed.), Frontiers in Econometrics, New York: Academic Press, 105–142.

Ministerie van Infrastructuur en Milieu (IenM). (2015). *Resultatenkrant Beter Benutten.* Retrieved from https://beterbenutten.nl/assets/upload/files/DeBeterBenuttenResultatenkrant_v6.pdf

Molin, E. J. (2011). Conjoint analysis. In *The measurement and analysis of housing preference and choice* (pp. 127-155). Springer, Dordrecht.

Molin, E. (2005). Causal analysis of hydrogen acceptance. *Transportation research record, 1941*(1), 115-121.

MuConsult B.V. (2013, November 2). *Eindevaluatie Mobiliteitsprojecten.* Retrieved from https://www.beterbenutten.nl/assets/upload/files/MuConsult%202013%20Eindrapport%20Mobiliteitsprojecten.pdf

Nederlandse Omroep Stichting (NOS). (2018a, November 21). *Files leiden tot ruim 1 miljard euro economische schade.* Retrieved from https://nos.nl/artikel/2260165-files-leiden-tot-ruim-1-miljard-euro-economische-schade.html

Nederlandse Omroep Stichting (NOS). (2018b, October 30). *Meer asfalt, het r-woord of toch het ov: hoe lossen we het fileprobleem op?* Retrieved from https://nos.nl/artikel/2257103-meer-asfalt-het-r-woord-of-toch-het-ov-hoe-lossen-we-het-fileprobleem-op.html

Nelson, T. E., & Oxley, Z. M. (1999). Issue framing effects on belief importance and opinion. *The journal of politics, 61*(4), 1040-1067.

Nieuwenhuizen Wijbenga, C. van., & Veldhoven-van der Meer, S. van. (2018, November 7). *Kabinetsreactie Rli adviesrapporten 'Dichterbij en sneller' en 'Van B naar anders'.* Retrieved from https://www.rijksoverheid.nl/documenten/kamerstukken/2018/11/07/kabinetsreactie-raad-voor-de-leefomgeving-en-infrastructuur-rli-adviesrapporten-dichterbij-en-sneller-en-van-b-naar-anders

Niskanen, E., de Palma, A., Lindsey, R., Marler, N., May, T., Nash, C., ... & KUL, T. (2003). Pricing of urban and interurban road transport: Barriers, constraints and implementation paths. *Implementation of Marginal Cost Pricing in Transport-Integrated Conceptual and Applied Model Analysis. Deliverable, 4.*

Norman, R., Kemmler, G., Viney, R., Pickard, A. S., Gamper, E., Holzner, B., ... & King, M. (2016). Order of presentation of dimensions does not systematically bias utility weights from a discrete choice experiment. *Value in Health, 19*(8), 1033-1038.

OECD (Organisation for Economic Cooperation and Development). (2001). *Domestic Transferable Permits for Environmental Management, Design and Implementation.* OECD, Paris.

Patterson, Z., Darbani, J. M., Rezaei, A., Zacharias, J., & Yazdizadeh, A. (2017). Comparing text-only and virtual reality discrete choice experiments of neighbourhood choice. *Landscape and Urban Planning, 157,* 63-74.

Raad voor Leefomgeving en Infrastructuur (RLI). (2018, May). *Van B naar anders. Investeren in mobiliteit voor de toekomst.* Retrieved from https://rli.nl/sites/default/files/rli_2018-04_van_b_naar_anders._investeren_in_mobiliteit_voor_de_toekomst._3-9-2018.pdf

Raux, C. (2007). Tradable driving rights in urban areas: their potential for tackling congestion and traffic-related pollution. *The Implementation and Effectiveness of Transport Demand Management Measures*, 95.

Raux, C. (2004). The use of transferable permits in transport policy. *Transportation Research Part D: Transport and Environment, 9*(3), 185-197.

Raux, C., Croissant, Y., & Pons, D. (2015). Would personal carbon trading reduce travel emissions more effectively than a carbon tax?. T*ransportation Research Part D: Transport and Environment, 35*, 72-83.

Rienstra, S. A., Rietveld, P., & Verhoef, E. T. (1999). The social support for policy measures in passenger transport.: A statistical analysis for the Netherlands. *Transportation Research Part D: Transport and Environment, 4*(3), 181-200.

Rijksoverheid. (2017, October 10). *Vertrouwen in de toekomst. Regeerakkoord 2017-2021. VVD, CDA, D66 en ChristenUnie.* Retrieved from https://www.rijksoverheid.nl/regering/documenten/publicaties/2017/10/10/regeerakkoord-2017-vertrouwen-in-de-toekomst

Rolfe, J., Bennett, J., & Louviere, J. (2002). Stated values and reminders of substitute goods: Testing for framing effects with choice modelling. A*ustralian Journal of Agricultural and Resource Economics, 46*(1), 1-20.

Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. *Journal of extension, 37*(2), 1-5.

Schade, J., & Schlag, B. (2003). Acceptability of urban transport pricing strategies. *Transportation Research Part F: Traffic Psychology and Behaviour, 6*(1), 45-61.

Schuitema, G., Steg, L., & Forward, S. (2010). Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. *Transportation Research Part A: Policy and Practice, 44*(2), 99-109.

Smaal, M. (2012). *Politieke strijd om de prijs van automobiliteit: De geschiedenis van een langdurend discours: 1895-2010.* Eburon Uitgeverij BV.

Smith, M. F., & Sinha, I. (2000). The impact of price and extra product promotions on store preference. *International Journal of Retail & Distribution Management, 28*(2), 83-92.

Starmer, C. (2000). Developments in non-expected utility theory: The hunt for a descriptive theory of choice under risk. *Journal of economic literature, 38*(2), 332-382.

Stevens, H. & Verhoef, E. (2013, March). *Marktwerking in het kader van het beter benutten van infrastructuur: verhandelbare spitsrechten?* Retrieved from http://dbr.verdus.nl/upload/documents/DBR_Notitie_04_Verhandelbare%20spitsrechten%20mrt%2013.pdf

Sugden, R. (2005). Anomalies and stated preference techniques: a framework for a discussion of coping strategies. *Environmental and Resource Economics, 32*(1), 1-12.

Sun, X., Feng, S., & Lu, J. (2016). Psychological factors influencing the public acceptability of congestion pricing in China. *Transportation research part F: traffic psychology and behaviour, 41*, 104-112.

Tietenberg, T. (2002). *The tradable permits approach to protecting the commons: What have we learned?*.

Tietenberg, T. H. (1980). Transferable discharge permits and the control of stationary source air pollution: a survey and synthesis. *Land economics, 56*(4), 391-416.

Train, K. E. (2009). *Discrete choice methods with simulation.* Cambridge university press.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211*(4481), 453-458.

Vass, C. M., Rigby, D., & Payne, K. (2018). Investigating the heterogeneity in women's preferences for breast screening: does the communication of risk matter?. *Value in Health, 21*(2), 219-228.

Veldwijk, J., Essers, B. A., Lambooij, M. S., Dirksen, C. D., Smit, H. A., & de Wit, G. A. (2016). Survival or mortality: does risk attribute framing influence decision-making behavior in a discrete choice experiment?. *Value in Health, 19*(2), 202-209.

Veldwijk, J., Lambooij, M. S., van Til, J. A., Groothuis-Oudshoorn, C. G., Smit, H. A., & de Wit, G. A. (2015). Words or graphics to present a Discrete Choice Experiment: Does it matter?. *Patient education and counseling, 98*(11), 1376-1384.

Verhoef, E., Nijkamp, P., & Rietveld, P. (1997-a). Tradeable permits: their potential in the regulation of road transport externalities. *Environment and Planning B: Planning and Design, 24*(4), 527-548.

Verhoef, E. (2018, July). *Verhandelbare spitsrechten als oplossing voor files.* Retrieved from https://spatialeconomics.nl/geslaagde-mix-verhandelbare-rechten-als-oplossing-voor-de-files/

Verhoef, E., Brands, D. & Knockaert, J. (n.d.). Verhandelbare mobiliteitsrechten: kansrijke piekmaatregel? *Stichting NM Magazine.* Retrieved from http://www.nm-magazine.nl/artikelen/verhandelbare-mobiliteitsrechten-kansrijke-piekmaatregel/

Volksgezondheidsmonitor Utrecht. (2018). *Opleiding en inkomen.* Retrieved from https://www.volksgezondheidsmonitor.nl/opleiding-en-inkomen-utrecht/page386.html

Volkskrant. (2016, November 17). *Waarom het rekeningrijden in Nederland nooit komt.* Retrieved from https://www.volkskrant.nl/nieuws-achtergrond/waarom-het-rekeningrijden-in-nederland-nooit-komt b561518a/

de Vries, G. (2017). How positive framing may fuel opposition to low-carbon technologies: The boomerang model. *Journal of Language and Social Psychology, 36*(1), 28-44.

de Vries, G., Terwel, B. W., & Ellemers, N. (2016). Perceptions of manipulation and judgments of illegitimacy: Pitfalls in the use of emphasis framing when communicating about CO2 capture and storage. *Environmental Communication, 10*(2), 206-226.

de Vries, G., Terwel, B. W., & Ellemers, N. (2014). Spare the details, share the relevance: The dilution effect in communications about carbon dioxide capture and storage. *Journal of Environmental Psychology, 38*, 116-123.

Xiao, F., Qian, Z. S., & Zhang, H. M. (2013). Managing bottleneck congestion with tradable credits. *Transportation Research Part B: Methodological, 56*, 1-14.

Xu, M., & Grant-Muller, S. (2016). Trip mode and travel pattern impacts of a Tradable Credits Scheme: A case study of Beijing. *Transport Policy, 47*, 72-83.

Yang, H., & Wang, X. (2011). Managing network mobility with tradable credits. *Transportation Research Part B: Methodological, 45*(3), 580-594.

Ziegler, M., & Hagemann, D. (2015). *Testing the Unidimensionality of items.*

A

Appendix: Search strategies literature reviews

Two literature reviews were conducted in two separate fields of literature in order to review the state of the art in these two fields (see Chapter 3). The search strategies used to find and select articles are discussed here.

It was first determined which questions needed to be answered by the literature reviews. For the first literature review these were the following:

- What is the background of tradable peak credits?
- What are current applications of tradable credit systems?
- In which research domains other than mobility are tradable credit systems studied and what insights does this provide?
- What has already been studied in the field of tradable peak credits and other systems with tradable driving credits for mobility management?
- What important knowledge gaps still exist regarding a tradable peak credit system?

For the second literature review, this was the following:

- What has already been studied about the influence of the way of presenting the choice task in a stated-choice experiment on the results of that experiment?

Both Scopus and Google Scholar were then used to search for articles. For the first literature review the following search terms were used and resulted in the following amounts of articles:

- (“Tradable” OR “Tradeable” OR “Transferable”) AND (“Permits” OR “Credits”) AND (“Driving” OR “Mobility” OR “Transport” OR “Peak” OR “Congestion”) - 165 articles in Scopus and 122.000 articles in Google Scholar
- (“Tradable” OR “Tradeable” OR “Transferable”) AND (“Permits” OR “Credits”) AND (“Carbon” OR “Emission”) - 682 articles in Scopus and 69.000 in Google Scholar
- (“Tradable” OR “Tradeable” OR “Transferable”) AND (“Permits” OR “Credits”) AND (“Driving” OR “Mobility” OR “Transport” OR “Peak” OR “Congestion”) AND (“Acceptability” OR “Acceptance” OR “Support”) - 11 articles in Scopus and 110.000 in Google Scholar

For the second literature review the following search terms were used and resulted in the following amounts of articles:

- (“Influence” OR “Effect”) AND (“Discrete choice experiment” OR “Discrete choice analysis” OR “Stated preference”) AND (“Framing” OR “Attribute” OR “Introduction” OR “Explanation” OR “Context”) - 1.211 articles in Scopus and 18.000 in Google Scholar

Selection criteria were defined for selecting articles. For the first literature review the selection criterion was that the paper should include some form of personal tradable permits. The selection criterion for the second literature review was that the paper investigates the impact of some aspect of the way in which the choice task is set up and presented to the respondent. In both literature studies, around 50 papers that were cited the most were scanned and assessed based on the selection criterion. Of the selected papers, the abstract and the conclusion were read to determine whether the papers were expected to be useful. Subsequently, backward and forward snowballing were used to search for more articles that met selection criteria.

B

Appendix: Literature review tradable driving credits

Table B.1: Overview of results literature review tradable driving credits

Author	Name system	System characteristics	Researched aspects	Methodology
Goddard (1997)	Tradeable Vehicle Use Permits	-A permit allows a driver to drive one day -Registered vehicles receive a specified amount of permits per week for free -All permits can 'be freely traded, bought, sold, leased, rented, lent, and unfortunately also stolen'	-'cost-effectiveness in attaining emissions targets' -'conditions for the permit market equilibria'	Mathematical programing
Raux (2004)	Domestic transferable permit systems (category)	Varying	-Arguments for and against use of permit system -Effectiveness in addressing greenhouse gas, emissions and congestion -Technical feasibility of permits system	Case study
Kockelman & Kalmanje (2005)	Credit-based congestion pricing (CBCP)	-'Drivers receive a monthly allowance of monetary travel "credits" to use on the roads' -'Time- and linkvarying prices' -Credits not tradable	-Perceptions of public in USA -Likely travel reactions of public -Aspects influencing the support of CBCP by public -Effectiveness in addressing congestion	Survey-based analysis
Raux (2007)	Tradable Driving Rights (TDR)	-A driving right represents either a trip or vehicle-kilometres travelled -The amount of driving rights required for driving are computed based on different parameters	Unclear	Qualitative analysis
Yang & Wang (2011)	Tradable travel credits	-The amount of credits required for driving on a certain roadway link differ per link -Credits are allocated to drivers by the government -There is a trademarket without government intervention	-Whether tradable credits can lead to 'desirable network flow patterns'	Mathematical programing
Xiao, Qian, & Zhang (2013)	Time-varying tradable credits system	-The credits required for driving somewhere depend on the time of driving -There is an initial distribution of credits over drivers -Credits can be freely traded	-Efficiency and effectiveness of tradable credit system	Mathematical programing
Stevens & Verhoef (2013)	Tradeable Peak Permits (TPP)	-Permits are required to drive during rush hours -Free permits are allocated to participants -Permits can be traded among participants	-Theoretical advantages of TPP system	Qualitative analysis

Author	Name system	System characteristics	Researched aspects	Methodology
Fan & Jiang (2013)	Tradable mobility permits (TMP) schemes (category)	Varying	-'similarities and variations among various TMP schemes' regarding 'congestion reduction, market mechanism, and equity issues'	Qualitative analysis
Gao & Sun (2014)	Tradable credits	Unclear	-'the existence of tradable credits scheme which decentralizes a given Pareto system optimum link flow pattern'	Economic analysis & Mathematical programming
Xu & Grant-Muller (2016)	Tradable Credits Scheme (TCS)	-'initial credit allocation is free' -'individuals receive a number of credits (representing vehicle-kilometers) based on a target of reducing the overall total VKT for the urban area'	-Effect on travelers' mode choice	Simulation & Case study
Dogterom (2017)	Tradeable Driving Credits (TDC)	- A credit represents one kilometer -Credits are required for all driven kilometres, 'irrespective of time and place' -Free credits are monthly allocated to all car-owners	-Behavioural changes due to TDC -Influence of several factors on willingness to change behavior and on actual change of behavior under TDC -Public acceptance of TDC -Influence of several factors on public acceptance of TDC	Empirical experiments & Survey-based analysis
Dogterom, Ettema & Dijst (2018)	Tradeable Driving Credits (TDC)	-One credit represents one kilometre, irrespective of time and location	-'drivers' responses to TDC schemes at the individual level' in terms of 'individual car travel patterns'	Empirical experiment

C

Appendix: Literature review influence presenting choice task

Table C.1: Overview of results literature review influence presenting choice task

Author	Aspect that was researched	Description	Method	Results
Veldwijk et al. (2016)	Risk attribute framing	'Test how risk attribute framing in a discrete choice experiment (DCE) affects respondents' decision-making behavior and their preferences'	-Two versions of a DCE questionnaire -'The risk attribute included was framed positively as the probability of surviving CRC and negatively as the probability of dying from CRC'.	-'The framing of the risk attribute significantly influenced all attribute-level estimates and resulted in different preference structures among respondents in the positively and negatively framed data set. ' -'Risk framing affects how respondents value the presented risk.'
Vass et al. (2018)	Risk communication	Effect of risk communication on women's preferences for the benefits and risks of a national breast screening program (NBSP)	'Survey respondents were randomized to one of two surveys, presenting risk either as percentages only or as icon arrays and percentages.'	'Risk communication format had no effect on preferences or choice consistency.'
Veldwijk et al. (2015)	Depicting attribute levels in words vs graphics	'Test whether presenting attribute levels in words or graphics generates different results with respect to attribute level interpretation, relative importance and participation probabilities.'	'Two versions of the same nine choice tasks in which the attribute levels were presented in words or graphics.'	-'This study shows that the way similar attribute levels are presented, either in graphics or in words, affects the results of the DCE.' -Depicting attribute levels in words resulted in 'more consistent answering patterns'. -Attribute levels were interpreted more accurately when depicted in words. -'Relative importance of the attributes differed when depicted in words or graphics.'
Norman et al. (2016)	Order effects	Test influence of the 'order in which dimensions of health are presented in the valuation task'	60 versions of survey, in which order of dimensions was randomized	-'The order of presentation of QOL dimensions within a DCE designed to provide utility weights for the QLU-C10D had little effect on level coefficients of those QOL dimensions'
Hensher (2006)	Amount of information (number of attributes in each choice set)	'Understanding what influences a respondent's decision to ignore (or not attend to) specific attributes in choosing amongst the offered alternatives'	'a suite of SC experiments in which we systematically vary the dimensionality of the experiment, and complement it with additional questions on how the SC task is processed.'	-'We find that the degree to which individuals ignore attributes is influenced by the dimensionality of the SC experiment, the deviation of attribute levels from an experienced reference alternative, the use of 'adding up' attributes where feasible, the number of choice sets evaluated, and the personal income of the respondent.'
Gendall et al. (2006)	Framing of price discount message	'examine the effect on consumers of the way in which price discount messages are expressed, or "framed"'	Stated preference choice modelling experiments	For expensive products, framing a discount in dollars was more effective than framing it in percentages
Rolfe et al. (2003)	Making the choice set wider	'test whether differences in framing the choices to respondents cause variations in the parameters of the resulting choice model'	Different choice experiments with different amounts of substitutes	The introduction of a wider choice set has impacted on the relative values of the different coefficients.
Howard & Salkeld (2009)	Attribute framing	'exploration of the effect of attribute framing on marginal rates of substitution (MRS), including willingness to pay (WTP) from a discrete choice experiment (DCE), within the context of colorectal cancer screening preferences.'	-'The potential benefits and harms of screening tests were presented in both positive and negative frames' -'Participants were randomized to one of four alternative "frames" of information.'	'Under some circumstances, framing of the attributes (e.g., cancers found vs. cancers missed) influenced the relative importance of attributes. Attribute framing significantly influenced estimates of WTP, and benefit: harm tradeoffs that were calculated from MRS.'
Smith & Sinha (2000)	Deal frames	'Examine the effect of three deal frames: one, stated in terms of a straight price promotion ("50 percent off"), the second, as an extra-product or volume promotion ("buy one, get one free"), and a third as a "mixed" promotion ("buy two, get 50 percent off")."	Controlled experiment	'Results show that the nature of framing significantly affects consumer deal preference and store preference even though the deals are equivalent on a unit cost basis and two of the deals are also equivalent on a total cost basis.'
Kragt & Bennett (2011)	Attribute framing (attribute level descriptions)	'In this study, the impacts of two attribute level descriptions are assessed: describing non-market attributes as absolute levels or in relative terms; and using positive versus negative contextual descriptions of attribute levels.	Choice experiment	'Contrary to a priori expectations, including explicit information cues about relative attribute levels in the choice sets is not found to affect stated preferences. The data do reveal significant differences in value estimates when attribute levels are described as a 'loss', compared to a 'presence'."

D

Appendix: Consultation of road pricing scientists

This appendix summarizes the most important insights gained during the discussions with road pricing scientists. Based on these insights, various iterations were made in drawing up the explanation of TPC and its attributes to respondents. The insights have also been used in selecting design variables, attributes, and their levels for the stated choice experiment.

D.1 Bert van Wee

Bert van Wee is a professor in transport policy at Delft University of Technology.

Introduction of TPC and its attributes to respondents

- Use simple language. TPC is a complex instrument. It is therefore important to keep the explanation as simple as possible so that the instrument is easier to understand for all respondents. For example, don't talk about 'trading opportunities' but say 'how can you trade'.
- Use more active language.
- Replace certain words with more neutral words. For example, do not say 'validity credits'. This can evoke a negative association in people. People can then think of existing annoyances about purchased products that expire.
- State explicitly that tradable peak credits are not a congestion charge. Make it clear that the government does not earn more or less money through this system. Adding this clarification is not intended to influence respondents, but to be more certain that respondents know how the system works before they indicate their preferences regarding this system.
- Say something about the information provision regarding this new system of tradable peak credits. How are citizens informed about this new system? If you say nothing about this, respondents can assume that you as a visitor can be surprised by the existence of this system and suddenly need credits.
- Discuss whether trading in credits is necessary or not. Is it also possible to just drive when you want, whereby the system buys credits if you do not have valid credits, and

sends you the bill at the end of the month? This could, in fact, increase acceptance among people who find trading an annoying aspect of the system.

Attributes

- There is probably interaction between the 'credit distribution' and 'credit receivers' attributes. It is likely that your opinion on how credits should be distributed depends on the recipients under which they are distributed. It is probably too complicated to take this into account in this study, but it is important to be aware of it.
- Recipients of credits
  For the levels where people who traveled in the area in the last month receive credits, you need to add information about how often this is updated. How often is it checked again who traveled in the area?
- Distribution of credits
  I would add the option that people with children receive more credits, because they probably have to drive more often.
- Purchase limits
  You could also have the option that you can buy up to as many credits as you could use yourself.

Questionnaire

- Add statements about how people think about trading in credits. Credit trading is an important aspect of this new system, and how you feel about this aspect can probably greatly influence your opinion about the system.
- For the 'other' answer option, also add a field where people can enter their answer. It is often possible to classify people who fill in 'other' into an answer category.
- Add to the explanation of a kilometer charge that the motor vehicle tax would then be abolished.

Greatest influence on opinions of respondents

Bert was asked which attributes he expects to have the most influence on what people think of the system with tradable peak credits. He mentioned the following:

- Perceived fairness
  Research into pricing policy shows that honesty is a very important factor and can be a showstopper. As a result, Bert expects that the recipients of credits and the method of distributing credits among them will be very influential.
- Attitudes regarding trading credits
  Since trading in credits has such a central place within this measure, the opinion on this trading will strongly influence the opinion on the system as a whole.
- Perceived effectiveness
  Whether people think the measure will reduce traffic jams is probably also very important.

D.2 Nico Dogterom

Nico Dogterom received his PhD in 2017 at the University of Utrecht for his research into the effects of tradable driving credits on individual car use. Currently he is working as a consultant in research and behavior at Goudappel Coffeng, which aims at solving mobility issues.

Introduction of TPC and its attributes to respondents

- Make clear why tradable peak credits are proposed as a measure. Why is this measure proposed as an alternative to a congestion charge?
- Make clear how cars will be detected. For example, are toll gates used or is it via GPS?
- Mention that the time of the start of the journey is considered to determine whether you are driving during peak hours.
- State the amount of the fine that drivers receive if they drive during peak hours without a valid permit.
- Explain a bit more about how the trading of credits will work. This ensures that respondents do not get a wrong impression of this, for example by thinking that they should look for a buyer themselves or actively negotiate a price.
- Choosing all highways and N roads in a certain area is a good decision. This is in line with the what the government envisages with regard to the truck charge they are going to introduce.
- How does the system deal with business traffic? Do companies receive credits? And does an employee who drives for his work pay his credits or does the company do that?
- Nico recommends not including the possibility that motorists just drive in peak hours where the system automatically buys credits for them when needed, and motorists receive a final bill. Credit trading is an essential part of the system. By making it possible not to trade credits, it becomes a completely different system.

Attributes

- Use simpler language. Avoid words like 'instrument' and 'effective'.
- Indeed, do not add an attribute about the extent to which credit trading is automated. This is too complex.

Greatest influence on opinions of respondents

Nico was asked which attributes he expects to have the most influence on what people think of the system with tradable peak credits. He mentioned the following:

- The recipients of credits and the method of distributing credits among them
  Literature shows that people find this distribution issue very important; the research of Nico also showed this.
- Maximum price of a credit
  If there is no maximum price, there can be a fear that only the rich can drive during peak hours.
- Price fluctuation
  People find variable information and uncertainty difficult.
- Purchase limits
  If there are no purchase limits, speculation can arise: people buying credits to make a profit when the price rises.

Nico believes that including the regulator of the system, the government or a private party, as an attribute is not insightful. People need more information about the consequences of when a government or private party manages the system to make a choice.

D.3 Paul Koster

Paul Koster is an assistant professor at the Department of Spatial Economics at the Vrije Universiteit Amsterdam. His research focuses on experimental valuation and the regulation of externalities and he has experience with advanced discrete choice econometrics.

Introduction of TPC and its attributes to respondents

- Add a map that shows the area and roads where the credits are needed.
- It is difficult to estimate the price range of the credit. Look at the societal price of a car ride and cordon tolls in cities to make an estimate based on this.

Attributes

- How often credits are distributed
  - It is not certain whether credits will be more effective if they are distributed weekly rather than monthly, so I would not state this.
  - People may prefer get monthly credits instead of weekly, because in a longer period you are often more flexible in organizing your activities than in a shorter period.
  - The government can also vary in how many credits it distributes for a certain period (the cap). For example, if bad weather is expected, congestion will arise with fewer cars. Then the government can decide to hand out fewer credits during that period. If you hand out credits for a month, you have little insight into the weather for that entire period and therefore you also have less insight in how much credits should be distributed. Then there is a chance that you will hand out more credits than the roads can handle before congestion occurs. When credits are distributed weekly, the government can change the cap more often and adjust it to the situation.
- The method of distributing credits among recipients
  - There are two levels that state that credits are distributed "largely equally". This is vague. Make this concrete, for example by saying that people who drive twice as often in the area also receive twice as many credits.
  - Explain why people with a lower income would receive more credits.
- Price fluctuation
  - Omit the level "every week," because you also have the option of distributing credits every week; then it is not logical that there is a fixed price for the entire week.
- Reselling purchased credits
  - It is good that you have an attribute that is designed to prevent speculation. However, I would not use this attribute, a prohibition on the resale of purchased credits. A disadvantage of this is that it imposes restrictions on trading, while you actually want to stimulate trading in this system. For example, people can accidentally buy a credit or suddenly don't need a credit anymore. Then it is a limitation that you can no longer sell it. Another way to design the system so that speculation and price boosting is not possible is to set a limit on how many credits people can buy. In a week you can make a maximum of 10 peak-hour trips, so you are only allowed a maximum of 10 credits in your possession that week. Also look at Davey's paper. A number of restrictions were imposed on the trade in the application from this paper.
- Include the following two aspects in your choice experiment: effectiveness of the peak credits and costs of the system.

– There is a trade-off between the costs for the system and the benefits of the system. If you ask people to choose between the introduction of tradable peak credits and the status quo, it is important that they know the personal benefits. So make it clear what the effect is on congestion of tradable peak credits. Also make clear what the annual fixed costs of this system would be for the government.

D.4 Erik Verhoef

Erik Verhoef is professor transport economics and head of the Department of Spatial Economics at the Vrije Universiteit Amsterdam. He investigates the pricing of mobility.

Introduction of TPC and its attributes to respondents

- Add an example of how TPC would work: outline the situation that a person normally makes x rush drives a week and receives y credits and explain what that means for this person.
- Do not state the specific costs that the system entails for the municipality, but explain that the costs depend on the area and the number of participants.
- Let the expected credit price range be 2 to 4 euros.
- Add that if people are on the road during rush hour, without having valid credits, they will be notified that they have time until the evening to buy a credit themselves.
- Let the transaction costs be 1 euro.
- Traffic jams will decrease by 25% or more due to TPC.

E

Appendix: Introduction to TPC versions

The introductory texts that were used in the survey are presented here. The sections of text that were added to the second introduction compared to the first introduction are highlighted.

E.1 Introduction version 'Explanation TPC'

Doordeweeks staan er vaak files in Nederland. Een nieuw plan voor het aanpakken van files is bedacht: verhandelbare spitscredits. (Let op: dit is iets anders dan een spitsheffing of rekeningrijden.)

Het basisidee is dat rijden tijdens de spits (op maandag t/m vrijdag, 07:00 - 09:15 & 16:00 - 18:15) met een personenauto een spitscredit kost op alle snelwegen en N-wegen in de gemeente Amsterdam. Ook als je tijdens één spits op meerdere wegen rijdt, kost dit één credit. Buiten de gemeente Amsterdam en buiten de spits zijn er geen credits nodig.

Het aantal credits dat beschikbaar is, hangt af van de capaciteit van het gebied. Een gebied dat maximaal 9.000 auto's per spits aan kan, krijgt dus 9.000 credits. Ten opzichte van de huidige situatie moeten er 10% minder auto's rijden om de meeste files op te lossen.

De credits worden gratis uitgedeeld en men kan deze credits dus gebruiken om tijdens de spits te rijden. De overheid beheert het systeem.

Als mensen credits over hebben, kunnen zij deze verkopen op een handelsplatform aan mensen die juist meer credits willen. Het kopen en verkopen kan via een app of via de computer. Je hoeft niet zelf een koper of verkoper te zoeken; je koopt en verkoopt de credit direct aan het handelsplatform tegen de prijs van dat moment. Het handelsplatform maakt geen winst. De overheid verdient ook geen geld, omdat automobilisten onderling credits verhandelen.

De prijs van de credits op het handelsplatform wordt bepaald door vraag en aanbod. Is er veel vraag, dan stijgt de prijs. Is er veel aanbod, dan zakt de prijs. De prijs van een credit zal naar verwachting ongeveer tussen de €2,- en €4,- liggen. De maximumprijs van een credit is €6,-.

Je kan maximaal zoveel credits bijkopen op het handelsplatform als je zelf zou kunnen gebruiken (dus in een week kan je maximaal 10 spitscredits in je bezit hebben, omdat je elke werkdag twee keer in de spits kan rijden). Dit voorkomt dat mensen veel credits kunnen kopen met het doel ze weer te verkopen en zo winst te maken.

Mensen kunnen hun auto registreren en dan wordt de credit automatisch van hun 'budget' afgeschreven als ze in de spits de weg op gaan. Als iemand de weg opgaat terwijl zijn credits op zijn, krijgt hij 's avonds een melding om alsnog een credit te kopen voor die rit. Als hij dit niet doet, koopt het systeem automatisch een credit voor hem tegen de handelsprijs van dat moment plus transactiekosten van €1,-.

Mensen die hun auto niet hebben geregistreerd (bijvoorbeeld bezoekers) kunnen eenmalig credits kopen voor een bepaald aantal dagen (online of bij een benzinestation).

Een voorbeeld: een automobilist die voorheen 8 keer per week in de spits reed, krijgt nu 7 credits. Als hij 8 keer in de spits blijft rijden, moet hij 1 credit bijkopen. Als hij 7 keer per week in de spits gaat rijden, hoeft hij niet te verkopen of bijkopen. Als hij minder dan 7 keer per week in de spits gaat rijden, heeft hij credits over die hij kan verkopen.

Door invoering van verhandelbare spitscredits zal vertraging veroorzaakt door files naar verwachting afnemen met 25% of meer.

E.2 Introduction version 'Explanation TPC & problem'

Doordeweeks staan er vaak files in Nederland. De verwachting is dat het aantal files de komende jaren verder zal toenemen als er geen maatregelen worden genomen. Deze files kosten automobilisten tijd en geven onzekerheid over hun reistijden. Ook zijn files slecht voor de economie, want het kost geld als vrachtwagens of werknemers stilstaan op de snelweg of moeten omrijden. Als de files blijven toenemen zal ook de finan schade blijven toenemen.

Een nieuw plan voor het aanpakken van files is bedacht: verhandelbare spitscredits. (Let op: dit is iets anders dan een spitsheffing of rekeningrijden.)

Het basisidee is dat rijden tijdens de spits (op maandag t/m vrijdag, 07:00 - 09:15 & 16:00 - 18:15) met een personenauto een spitscredit kost op alle snelwegen en N-wegen in de gemeente Amsterdam. Ook als je tijdens één spits op meerdere wegen rijdt, kost dit één credit. Buiten de gemeente Amsterdam en buiten de spits zijn er geen credits nodig.

Het aantal credits dat beschikbaar is, hangt af van de capaciteit van het gebied. Een gebied dat maximaal 9.000 auto's per spits aan kan, krijgt dus 9.000 credits. Ten opzichte van de huidige situatie moeten er 10% minder auto's rijden om de meeste files op te lossen.

De credits worden gratis uitgedeeld en men kan deze credits dus gebruiken om tijdens de spits te rijden. De overheid beheert het systeem.

Als mensen credits over hebben, kunnen zij deze verkopen op een handelsplatform aan mensen die juist meer credits willen. Het kopen en verkopen kan via een app of via de computer. Je hoeft niet zelf een koper of verkoper te zoeken; je koopt en verkoopt de credit direct aan het handelsplatform tegen de prijs van dat moment. Het handelsplatform maakt geen winst. De overheid verdient ook geen geld, omdat automobilisten onderling credits verhandelen.

De prijs van de credits op het handelsplatform wordt bepaald door vraag en aanbod. Is er veel vraag, dan stijgt de prijs. Is er veel aanbod, dan zakt de prijs. De prijs van een credit zal naar verwachting ongeveer tussen de €2,- en €4,- liggen. De maximumprijs van een credit is €6,-.

Je kan maximaal zoveel credits bijkopen op het handelsplatform als je zelf zou kunnen gebruiken (dus in een week kan je maximaal 10 spitscredits in je bezit hebben, omdat je elke werkdag twee keer in de spits kan rijden.). Dit voorkomt dat mensen veel credits kunnen kopen met het doel ze door te verkopen en zo winst te maken.

Mensen kunnen hun auto registreren en dan wordt de credit automatisch van hun 'budget' afgeschreven als ze in de spits de weg op gaan. Als iemand de weg opgaat terwijl zijn credits op zijn, krijgt hij 's avonds een melding om alsnog een credit te kopen voor die rit. Als hij dit niet doet, koopt het systeem automatisch een credit voor hem tegen de handelsprijs van dat moment plus transactiekosten van €1,-.

Mensen die hun auto niet hebben geregistreerd (bijvoorbeeld bezoekers) kunnen eenmalig credits kopen voor een bepaald aantal dagen (online of bij een benzinestation).

Een voorbeeld: een automobilist die voorheen 8 keer per week in de spits reed, krijgt nu 7 credits. Als hij 8 keer in de spits blijft rijden, moet hij 1 credit bijkopen. Als hij 7 keer per week in de spits gaat rijden, hoeft hij niet te verkopen of bij te kopen. Als hij minder dan 7 keer per week in de spits gaat rijden, heeft hij credits over die hij kan verkopen.

Onderzoekers verwachten dat spitscredits de files sterk verminderen, doordat het uitdelen van credits controle geeft over hoeveel auto's in de spits kunnen rijden. Door invoering van verhandelbare spitscredits zal vertraging veroorzaakt door files naar verwachting afnemen met 25% of meer. Dit zorgt er dus voor dat automobilisten minder in de file staan en daardoor minder tijdverlies en onzekerheid over hun aankomsttijd hebben.

F

Appendix: Discrete choice modeling theory

Choices of respondents from sets of two TPC systems, and choices between a TPC system and the current situation were observed with a stated choice experiment. Discrete choice models were subsequently used to analyse this choice behavior (Koppelman & Bhat, 2006). This provides insight into the preferences of people with regard to attributes of the TPC systems, and the relative influence of these attributes on the decision-making (Koppelman & Bhat, 2006). This also allows to predict future choices of people (Koppelman & Bhat, 2006). In practice, this is often used to predict market shares of products or services. In this research, it is used to predict how many people prefer the introduction of a TPC system over maintaining the current situation, over the introduction of a congestion charge and over the introduction of a kilometer charge.

Utility maximization

Various discrete choice models exist to analyze choice behavior. The most commonly used models, which were also used in this study, are based on the random utility maximization (RUM) theory. These models assume utility maximization as the decision rule (Train, 2009). This means that an individual will choose the alternative that maximizes his or her utility (Koppelman & Bhat, 2006). Utility is 'an indicator of value to an individual' (Koppelman & Bhat, 2006, p.14). In this study this means that the TPC system that has the highest utility for an individual is chosen.

The total utility (U) of an alternative (i) for an individual consists of two parts: the systematic utility (V_i) and the error term (ϵ_i). Only a subset of factors that influences the choice of an individual for a TPC system is observed in the stated choice experiment. The observed factors are both the attributes of the TPC systems that are presented in the choice task (e.g. the recipients of credits) and the variables that were measured in the survey (e.g. the age of the respondent) (Koppelman & Bhat, 2006). The utility that can be related to these observed factors is the systematic utility. The utility that can be related to the unobserved factors is captured in the error term. The total utility of alternative i is thus expressed as:

$$U_i = V_i + \epsilon_i \tag{F.1}$$

The systematic utility is composed by the set of observed attributes and the parameters (β) that are estimated for each of these attributes (Koppelman & Bhat, 2006). The parameters denote

the relative contribution of the attribute to the utility. The systematic utility of alternative i that has m attributes (x) can therefore be expressed as follows:

$$V_i = \Sigma_m \beta_m * x_{im} \tag{F.2}$$

Based on the observed choices in the stated choice experiment, the parameters for the attributes (β's) are estimated using the maximum likelihood principle (Koppelman & Bhat, 2006). This means that the set of parameters is found which makes the choice data most likely. Subsequently, the above formulas can be used to calculate the systematic utility of all TPC systems. Note however that due to the unobserved factors, there is no certainty that an individual will opt for the alternative with the highest systematic utility (Bristow, 2010).

Utility functions in this study
In the stated choice experiment, there will be three alternatives from which respondents choose: TPC system 1, TPC system 2 or no TPC system. Every alternative has its own utility function, that determines the utility of that alternative. The utility function of 'no TPC system' is equal to zero. The utility functions of the TPC systems are among other things formed by the attributes of the TPC alternatives and the estimated betas. However, the utility function can be expanded with more components. This is discussed in the following section.

Components of the utility function
The attributes (x) and their parameters (β) are a basic part of the utility function. In addition, a utility function can also contain an alternative specific constant (ASC). This ASC captures the preference for an alternative that cannot be explained by the observed factors (Koppelman & Bhat, 2006). More formally, it represent the total average utility associated with unobserved factors of an alternative. In this study, the utility function of the TPC alternatives contain a ASC that captures the general preference for TPC compared to maintaining the current situation.

The utility function can also be extended with interaction-effects. This means that the utility contribution of a factor is dependent on the value of another factor. For example, the utility contribution of a certain way of distributing credits among recipients is dependent on the age of a respondent.

Choice probabilities
The utility of alternatives is used to calculate choice probabilities: the chance that an individual will choose a certain alternative from a set. In this study, we are interested in the chance that an individual prefers the introduction of a TPC system over maintaining the current situation. In order to calculate these choice probabilities it is however necessary to make an assumption on the probability distribution of ε (Koppelman & Bhat, 2006; Bristow, 2010). Different choice models make different assumptions. The different models will be discussed in the next section.

Choice models

Multinomial Logit model
The multinomial logit (MNL) model proposed by McFadden (1974) is the most widely used model (Train, 2009). A reason for this is that the model is simple to estimate, due to the fact that the formula of choice probabilities is closed form (Train, 2009). The MNL model assumes that 'errors associated with each option have a type I extreme value distribution and are independently and identically distributed' (i.i.d.) (Bristow, 2010) across alternatives and across observations. This means that the errors all have the same probability distribution and

that they are all mutually independent. The probability of choosing alternative i from a set of j alternatives can be computed with the following formula (Koppelman & Bhat, 2006)):

$$P(i) = \frac{exp(V_i)}{\Sigma_{j=1...J} exp(V_J)} \tag{F.3}$$

This formula is used to calculate the probability that people choose the introduction of a TPC system over maintaining the current situation.

The main drawbacks of the MNL are related to the assumption of the distribution of the error term. The mixed logit model that is discussed next deals with these drawbacks.

Mixed logit model

Important limitations of the MNL model are prevented in the mixed logit (ML) model due to three characteristics of ML models. First of all, they can capture nesting effects. MNL models ignore the existence of nests of alternatives that are similar in observed and unobserved attributes. If alternatives are similar, their error terms may be correlated. When that is the case, the i.i.d. assumption does not hold. Assuming an i.i.d. error distribution incorrectly can lead to biased parameter estimates. ML models solve this by adding an additional error component, υ, to the utility function. This error component represents the utility of the common unobserved factors of alternatives in a nest. The choice probabilities can then be calculated with:

$$P(i) = \int_{\upsilon} [(P_i|\upsilon) \cdot f(\upsilon)] d\upsilon \tag{F.4}$$

Secondly, ML models can capture taste heterogeneity. The MNL model wrongly assumes that tastes for attributes do not vary across individuals, by having fixed β's. MNL ignores correlations between unobserved utilities of alternatives with similar attributes. ML models can capture this unobserved taste heterogeneity, by letting one or more parameters (β's) vary across individuals with density f(β) (Train, 2009). The parameters of the distribution of the parameters are estimated. The choice probabilities can then be calculated with:

$$P(i) = \int_{\upsilon} \int_{\beta} [(P_i|\upsilon, \beta) \cdot f(\upsilon, \beta)] d\upsilon d\beta \tag{F.5}$$

This choice probabilities can be calculated through simulation. This means that parameter estimated are iteratively improved by making draws from probability density functions, evaluating conditional choice probabilities for the alternatives, and repeating this many times to compute the simulated average choice probabilities.

Thirdly, ML models can capture panel effects. Panel data is a sequence of choices made by one individual (Train, 2009). The MNL model wrongly assume that choices made by the same individual are uncorrelated. It is realistic that they are correlated, since individuals have tastes and preferences that influence their choices. By assuming that the choices are uncorrelated, the model will underestimate the standard errors of parameters. ML models can solve this problem by capturing panel effects, which means that the choices that are made over time by an individual are correlated. Again simulation is applied to calculate choice probabilities, but

now each draw is used to compute the entire sequence of choice probabilities for an individual. This means that the choice probabilities are calculated with:

$$P(i) = \int_{\upsilon,\beta} (\prod_{t=1}^{T} P(i|\upsilon,\beta) \cdot f(\upsilon,\beta)) d\upsilon d\beta \tag{F.6}$$

where 't' is a certain choice situation faced by the individual.

Model fit

Different choice models have now been discussed. In this study, both a MNL model and a ML model are estimated. In order to determine which model will be used to answer the research questions, it must be determined which model fits the observed choices best. This can be compared using a statistical test. The log-likelihood is a measure for the model fit. However, the model is based on a sample and therefore it is possible that a higher log-likelihood is based on coincidence. The likelihood ratio test can be used to assess whether the differences in log-likelihoods are significant (Koppelman & Bhat, 2006). This test also corrects for the difference in number of parameters between the models.

The rho-square value (ρ^2) is also a widely-used measure for the goodness of fit of a model (Koppelman & Bhat, 2006). It can be estimated using formula x:

$$\rho^2 = 1 - \frac{LL_\beta}{LL_0} \tag{F.7}$$

Here, LL_0 is the null-log-likelihood, which is the log-likelihood of the model when all parameters are set to zero. LL_β is the log-likelihood of the estimated model. ρ^2 can be interpreted as the percentage f initial uncertainty that is explained away by the model. The value of ρ^2 thus lies between 0 and 1. A value of 1 implies a perfect model fit, meaning that every choice is predicted correctly. There is however no guideline for what a good value of ρ^2 is. The rho-squared value will always increase when variables are added to the model, independent of how significant these variables are. The adjusted rho-squared penalizes the addition of variables that do not improve the model.

Appendix: Pilot survey feedback

This appendix explains what adjustments were made to the survey based on feedback from the pilot survey.

- The introduction to tradable peak credits is made more concise.spondents think the introduction is long and would like to see it more concise. They point to a number of things that they believe are double-headed, can be omitted, or can be formulated more concisely. These suggestions were used to shorten the introduction and make it more concise.
- A clarification has been added that a ride on multiple roads costs one credit.r some respondents it was not clear whether it would cost them several credits if they use different roads during one rush-hour drive. If respondents wrongly assume this, this might influence the results since it makes the system more complex. It has therefore been decided to clarify this.
- A clarification has been added that only those credits can be purchased that people decide to sell.r a number of respondents it was unclear that there is not an infinite amount of credits available to purchase. It has therefore been clarified that you can only buy credits that others make available.
- The formulation of some attribute levels is adjusted.umber of ambiguities in the formulation of attribute levels have been addressed.
- Explanation has been added that people should assess the statements about TPC with the TPC system as explained in the introduction in mind. the statements about TPC, people indicated that their answer to the statements would depend on the specific design of TPC. This was for example the case for the statement that TPC is a fair system. It was decided to ask people to answer the statements with the TPC system as explained in the introduction in mind, so without knowledge on design choices regarding the attributes.
- A simple design of choice sets has been chosen.spondents were presented with two designs of choice sets and were asked for their preference. One design was a very simple table. The other design attempted to make the choice set more visually appealing, among other things by using color. The majority of the respondents preferred the simple table design.
- For the questions about the extent to which you are in favor of the introduction of various road pricing measures on a scale of 1 to 5, one respondent indicated that you are either

for or against something. However, it has been decided to maintain this scale instead of asking whether respondents are for or against. There can be a difference in your conviction if you are in favor of something: you can lean slightly toward being in favor, or you can be totally convinced. Moreover, when someone is in favor of several measures, it can be distinguished whether he is more in favor of measure x than measure y.

H

Appendix: Experimental design of stated choice experiment

The software package Ngene was used to obtain an experimental design. In order to obtain this design, utilities functions of the alternatives were formulated. Since all attributes are categorical variables, all attributes had to be coded. As there is no clear reference category for all attributes, it was chosen to apply effects coding. This led to the utility function presented in H.1 for both alternatives in each choice set.

$$\begin{aligned} U_{TPC} = {} & \beta_{interval} \cdot Interval + \beta_{recipients1} \cdot Recipients1 + \beta_{recipients2} \cdot Recipients2 \\ & + \beta_{recipients3} \cdot Recipients3 + \beta_{distribution1} Distribution1 + \beta_{distribution2} \cdot Distribution2 \\ & + \beta_{distribution3} \cdot Distribution3 + \beta_{fluctuation} \cdot Fluctuation \end{aligned} \tag{H.1}$$

The following syntax was then used in Ngene to obtain the experimental design:

```
design
;alts = tpc1, tpc2
;rows = 12
;orth = seq
;block = 2
;model:
U(tpc1) = b1.effects[0] * interval[0,1] + b2.effects[0|0|0] * recipients[0,1,2,3] + b3.effects[0|0|0] *
distribution[0,1,2,3] + b4.effects[0] * fluctuation[0,1]/
U(tpc2) = b1 * interval + b2 * recipients + b3 * distribution + b4 * fluctuation
$
```

The experimental design obtained with Ngene is shown in Figure H.1. The attribute levels are coded in this design; which code belongs to which attribute level is given in Table H.1. The choice sets for the survey were thus obtained by replacing the codes in this experimental design with the corresponding attribute levels.

Choice situation	Recipients1	Interval1	Distribution1	Fluctuation1	Recipients2	Interval2	Distribution2	Fluctuation2	Block
1	3	0	2	1	2	1	1	1	2
2	0	1	0	1	0	1	3	0	2
3	2	0	3	0	1	1	2	0	2
4	2	1	1	1	2	0	3	0	1
5	1	0	1	0	3	0	2	1	2
6	1	1	2	0	3	1	0	0	1
7	0	1	3	0	1	0	1	1	2
8	3	1	0	0	2	0	0	0	2
9	1	0	1	1	0	1	0	1	1
10	0	0	2	1	1	0	1	0	1
11	2	0	0	0	3	1	3	1	1
12	3	1	3	1	0	0	2	1	1

Figure H.1: Experimental design

Table H.1: Overview of TPC attributes and levels and their codes as indicated in the experimental desing

Attribute	**Levels and codes**
Credit allocation interval	Weekly. (0) Monthly. (1)
Eligible recipients of free credits	All residents of the municipality. (0) All residents of the municipality who own a car. (1) All residents of the municipality + people who work there. (2) All residents of the municipality + people who work there and own a car. (3)
Distribution principle	Credits are equally distributed among all recipients. (0) People who have traveled more km will receive more credits. (1) People who work more hours per week receive more credits than people who work less hours per week. (2) People with a lower income receive more credits than people with a higher income. (3)
Credit price fluctuation	Every minute. (0) Every day. (1)

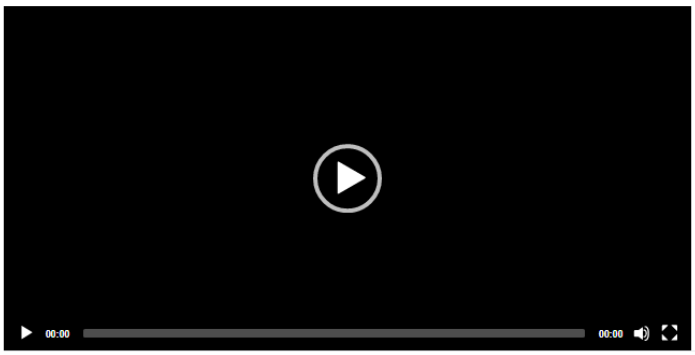
Appendix: Final survey

Respondents received the explanation of TPC either via video or via written text:

Enquête verhandelbare spitscredits - Amsterdam

Uitleg verhandelbare spitscredits 1

Eerst volgt een video met uitleg over wat verhandelbare spitscredits zijn. Daarna stellen we u een aantal vragen over uw mening over dit systeem.
Het is belangrijk dat u de video goed bekijkt voordat u doorgaat naar de vragen erover.



Back

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Tijd tot het mogelijk is om door te gaan naar de volgende pagina: 0:02:37

Enquête verhandelbare spitscredits - Amsterdam

Uitleg verhandelbare spitscredits (deel 1/3)

Eerst volgt een uitleg over wat verhandelbare spitscredits zijn. Daarna stellen we u een aantal vragen over uw mening over dit systeem.
Het is belangrijk dat u de volgende informatie goed leest voordat u doorgaat naar de vragen erover.

Doordeweeks staan er vaak files in Nederland. De verwachting is dat het aantal files de komende jaren verder zal toenemen als er geen maatregelen worden genomen. Deze files kosten automobilisten tijd en geven onzekerheid over hun reistijden. Ook zijn files slecht voor de economie, want het kost geld als vrachtwagens of werknemers stilstaan op de snelweg of moeten omrijden. Als de files blijven toenemen zal ook de financiële schade blijven toenemen.

Een nieuw plan voor het aanpakken van files is bedacht: verhandelbare spitscredits. (Let op: dit is iets anders dan een spitsheffing of rekeningrijden.)

Het basisidee is dat rijden tijdens de spits (op maandag t/m vrijdag, 07:00 - 09:15 & 16:00 - 18:15) met een personenauto een spitscredit kost op alle snelwegen en N-wegen in de gemeente Amsterdam. Ook als je tijdens één spits op meerdere wegen rijdt, kost dit één credit. Buiten de gemeente Amsterdam en buiten de spits zijn er geen credits nodig.

Het aantal credits dat beschikbaar is, hangt af van de capaciteit van het gebied. Een gebied dat maximaal 9.000 auto's per spits aan kan, krijgt dus 9.000 credits. Ten opzichte van de huidige situatie moeten er 10% minder auto's rijden om de meeste files op te lossen.

De credits worden gratis uitgedeeld en men kan deze credits dus gebruiken om tijdens de spits te rijden. De overheid beheert het systeem.

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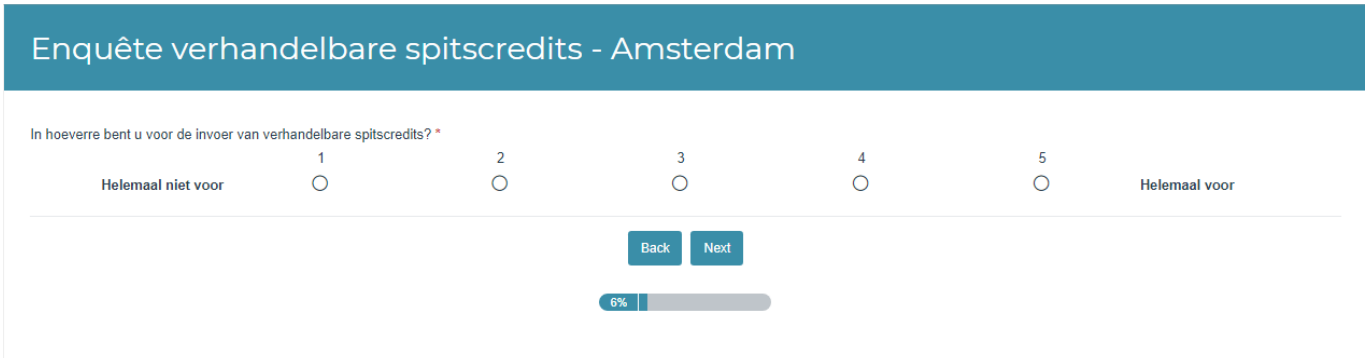
From this point on, respondents received the same screens, except for the choice sets, since there were two blocks of choice sets. Only one block of six choice sets is displayed here.



Enquête verhandelbare spitscredits - Amsterdam

Voorbeeld keuze

U krijgt straks 6 keer een keuze voorgelegd tussen twee systemen van verhandelbare spitscredits. Bij elk van de 6 keuzes verschillen de systemen in een aantal kenmerken van elkaar. U krijgt steeds 2 vragen:

- Welk systeem heeft uw voorkeur?
- Wat zou u stemmen als u de keuze zou krijgen: voor of tegen de invoer van het systeem van verhandelbare spitscredits van uw voorkeur? Denkt u zich hierbij in dat u tijdens een referendum deze opties voorgelegd zou krijgen en zou kunnen stemmen.

Hieronder ziet u een voorbeeld:

	Spitscredits systeem 1	**Spitscredits systeem 2**
Hoe vaak worden credits uitgedeeld?	Wekelijks	Maandelijks
Wie krijgen credits?	Inwoners + werknemers Amsterdam	Inwoners + werknemers met auto Amsterdam
Hoe worden credits verdeeld?	Gelijke verdeling	Mensen met lagere inkomens krijgen meer credits
Hoe vaak verandert creditprijs?	Elke minuut	Elke dag

Let op! De 6 keuzes lijken op het eerste oog steeds op elkaar, maar de kenmerken van de systemen waartussen u moet kiezen zijn steeds anders. De systemen verschillen van elkaar op de volgende kenmerken:

1. Hoe vaak de gratis credits worden uitgedeeld

- Wekelijks. Elk weekend krijgt men de credits voor de aankomende week. Deze credits zijn de hele week geldig. Na deze week vervallen de credits die niet zijn gebruikt.
- Maandelijks. Elke eerste dag van de maand krijgt men de credits voor de aankomende maand. Deze credits zijn de hele maand geldig. Na deze maand vervallen de credits die niet zijn gebruikt.

2. Wie gratis credits ontvangen
(Alleen mensen van 18 jaar of ouder ontvangen credits.)

- Alle inwoners van de gemeente Amsterdam.
- Alle inwoners van de gemeente Amsterdam die een auto bezitten.
- Alle inwoners van de gemeente Amsterdam + mensen die er werken.
- Alle inwoners van de gemeente Amsterdam + mensen die er werken en een auto bezitten.

2. Wie gratis credits ontvangen
(Alleen mensen van 18 jaar of ouder ontvangen credits.)

- Alle inwoners van de gemeente Amsterdam.
- Alle inwoners van de gemeente Amsterdam die een auto bezitten.
- Alle inwoners van de gemeente Amsterdam + mensen die er werken.
- Alle inwoners van de gemeente Amsterdam + mensen die er werken en een auto bezitten.

3. De verdeling van de gratis credits

- Credits worden gelijk verdeeld over alle ontvangers.
- Mensen die de afgelopen maand meer km hebben gereisd in het gebied waar credits nodig zijn, krijgen meer credits dan mensen die minder hebben gereisd.
- Mensen die meer uur werken per week krijgen meer credits dan mensen die minder uur werken per week.
- Mensen die een lager inkomen hebben, krijgen meer credits dan mensen met een hoger inkomen.

4. Wisseling van creditprijs
Hoe vaak de prijs die je betaalt voor een credit (prijs die de verkoper verdient) kan veranderen.

- Elke minuut.
- Elke dag.

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Enquête verhandelbare spitscredits - Amsterdam

Keuze 1 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Maandelijks	Wekelijks
Wie krijgen credits?	Inwoners + werknemers Amsterdam	Inwoners + werknemers Amsterdam
Hoe worden credits verdeeld?	Mensen die meer km hebben gereisd in het gebied krijgen meer credits	Mensen met lagere inkomens krijgen meer credits
Hoe vaak verandert creditprijs?	Elke dag	Elke minuut

Welk spitscredits systeem heeft uw voorkeur? *

- ○ Spitscredits systeem 1
- ○ Spitscredits systeem 2

Wat zou u stemmen? *

- ○ Voor de invoer van het door mij gekozen spitscredits systeem
- ○ Tegen de invoer van het door mij gekozen spitscredits systeem

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Enquête verhandelbare spitscredits - Amsterdam

Keuze 2 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Maandelijks	Maandelijks
Wie krijgen credits?	Inwoners Amsterdam met auto	Inwoners + werknemers met auto Amsterdam
Hoe worden credits verdeeld?	Mensen die meer uur werken krijgen meer credits	Gelijke verdeling
Hoe vaak verandert creditprijs?	Elke minuut	Elke minuut

Welk spitscredits systeem heeft uw voorkeur? *

- ○ Spitscredits systeem 1
- ○ Spitscredits systeem 2

Wat zou u stemmen? *

- ○ Voor de invoer van het door mij gekozen spitscredits systeem
- ○ Tegen de invoer van het door mij gekozen spitscredits systeem

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16%

Enquête verhandelbare spitscredits - Amsterdam

Keuze 3 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Wekelijks	Maandelijks
Wie krijgen credits?	Inwoners Amsterdam met auto	Inwoners Amsterdam
Hoe worden credits verdeeld?	Mensen die meer km hebben gereisd in het gebied krijgen meer credits	Gelijke verdeling
Hoe vaak verandert creditprijs?	Elke dag	Elke dag

Welk spitscredits systeem heeft uw voorkeur? *

- ◯ Spitscredits systeem 1
- ◯ Spitscredits systeem 2

Wat zou u stemmen? *

- ◯ Voor de invoer van het door mij gekozen spitscredits systeem
- ◯ Tegen de invoer van het door mij gekozen spitscredits systeem

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19%

Enquête verhandelbare spitscredits - Amsterdam

Keuze 4 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Wekelijks	Wekelijks
Wie krijgen credits?	Inwoners Amsterdam	Inwoners Amsterdam met auto
Hoe worden credits verdeeld?	Mensen die meer uur werken krijgen meer credits	Mensen die meer km hebben gereisd in het gebied krijgen meer credits
Hoe vaak verandert creditprijs?	Elke dag	Elke minuut

Welk spitscredits systeem heeft uw voorkeur? *

- ◯ Spitscredits systeem 1
- ◯ Spitscredits systeem 2

Wat zou u stemmen? *

- ◯ Voor de invoer van het door mij gekozen spitscredits systeem
- ◯ Tegen de invoer van het door mij gekozen spitscredits systeem

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Enquête verhandelbare spitscredits - Amsterdam

Keuze 5 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Wekelijks	Maandelijks
Wie krijgen credits?	Inwoners + werknemers Amsterdam	Inwoners + werknemers met auto Amsterdam
Hoe worden credits verdeeld?	Gelijke verdeling	Mensen met lagere inkomens krijgen meer credits
Hoe vaak verandert creditprijs?	Elke minuut	Elke dag

Welk spitscredits systeem heeft uw voorkeur? *

- ◯ Spitscredits systeem 1
- ◯ Spitscredits systeem 2

Wat zou u stemmen? *

- ◯ Voor de invoer van het door mij gekozen spitscredits systeem
- ◯ Tegen de invoer van het door mij gekozen spitscredits systeem

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Enquête verhandelbare spitscredits - Amsterdam

Keuze 6 van de 6

	Spitscredits systeem 1	Spitscredits systeem 2
Hoe vaak worden credits uitgedeeld?	Maandelijks	Wekelijks
Wie krijgen credits?	Inwoners + werknemers met auto Amsterdam	Inwoners Amsterdam
Hoe worden credits verdeeld?	Mensen met lagere inkomens krijgen meer credits	Mensen die meer uur werken krijgen meer credits
Hoe vaak verandert creditprijs?	Elke dag	Elke dag

Welk spitscredits systeem heeft uw voorkeur? *

- ◯ Spitscreditssysteem 1
- ◯ Spitscreditssysteem 2

Wat zou u stemmen? *

- ◯ Voor de invoer van het door mij gekozen spitscredits systeem
- ◯ Tegen de invoer van het door mij gekozen spitscredits systeem

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28%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Mobiliteitsgewoonten (deel 1/2)

Er worden u nu nog een aantal stellingen en vragen voorgelegd.

1. Met welk vervoersmiddel legt u de grootste afstand af op een gemiddelde doordeweekse dag?
(Het gaat hierbij om alle verplaatsingen die u maakt (voor werk of privé). Dus als u vaak 1 km fietst naar een treinstation om vervolgens 50 km met de trein af te leggen, kies dan 'trein'.) *

- ◯ Auto (als bestuurder)
- ◯ Auto (als passagier)
- ◯ Trein
- ◯ Tram/metro
- ◯ Bus
- ◯ Motor
- ◯ Brommer/scooter
- ◯ Fiets/elektrische fiets
- ◯ Lopen
- ◯ Anders - namelijk:

2. Heeft u een autorijbewijs? *

- ◯ Ja
- ◯ Nee

3. Kunt u altijd over een auto beschikken? *

- ◯ Ja, wanneer ik maar wil
- ◯ Nee, dat gaat in overleg met mensen binnen mijn huishouden

3. Kunt u altijd over een auto beschikken? *

- ◯ Ja, wanneer ik maar wil
- ◯ Nee, dat gaat in overleg met mensen binnen mijn huishouden
- ◯ Nee, dat gaat in overleg met mensen buiten mijn huishouden
- ◯ Nee, (vrijwel) nooit

4. Hoe vaak rijdt u auto? *

- ◯ (Vrijwel) elke dag
- ◯ 5-6 dagen per week
- ◯ 3-4 dagen per week
- ◯ 1-2 dagen per week
- ◯ 1-3 dagen per maand
- ◯ 6-11 dagen per jaar
- ◯ 1-5 dagen per jaar
- ◯ Minder dan 1 dag per jaar

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31%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Mobiliteitsgewoonten (deel 2/2)

5. Hoe vaak rijdt u met de auto in de ochtendspits (07:00 - 09:15) op maandag tot en met vrijdag? *

- ◯ 5 dagen per week
- ◯ 4 dagen per week
- ◯ 3 dagen per week
- ◯ 2 dagen per week
- ◯ 1 dag per week
- ◯ Minder dan 1 dag per week

6. Hoe vaak staat u in de file of langzaam rijdend verkeer tijdens uw ritten in de ochtendspits (07:00 - 09:15) op maandag tot en met vrijdag? *

- ◯ 5 dagen per week
- ◯ 4 dagen per week
- ◯ 3 dagen per week
- ◯ 2 dagen per week
- ◯ 1 dag per week
- ◯ Minder dan 1 dag per week

7. Hoe vaak rijdt u met de auto in de avondspits (16:00 - 18:15) op maandag tot en met vrijdag? *

- ◯ 5 dagen per week
- ◯ 4 dagen per week
- ◯ 3 dagen per week
- ◯ 2 dagen per week
- ◯ 1 dag per week

7. Hoe vaak rijdt u met de auto in de avondspits (16:00 - 18:15) op maandag tot en met vrijdag? *

- ◯ 5 dagen per week
- ◯ 4 dagen per week
- ◯ 3 dagen per week
- ◯ 2 dagen per week
- ◯ 1 dag per week
- ◯ Minder dan 1 dag per week

8. Hoe vaak staat u in de file of langzaam rijdend verkeer tijdens uw ritten in de avondspits (16:00 - 18:15) op maandag tot en met vrijdag? *

- ◯ 5 dagen per week
- ◯ 4 dagen per week
- ◯ 3 dagen per week
- ◯ 2 dagen per week
- ◯ 1 dag per week
- ◯ Minder dan 1 dag per week

9. Krijgt u de woon-werk reiskosten die u maakt vergoed? *

- ◯ Ja, volledig
- ◯ Ja, deels
- ◯ Nee, die krijg ik niet vergoed
- ◯ Ik heb geen woon-werk reiskosten

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34%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Verhandelbare spitscredits (deel 1/3)

U krijgt nu een aantal stellingen voorgelegd over verhandelbare spitscredits. Eerder kreeg u steeds twee vormen van verhandelbare spitscredit systemen te zien. Dit is nu niet het geval. Beantwoord deze vragen met de algemene maatregel zoals toegelicht aan het begin van deze enquête in gedachten, los van de specifieke vorm.

10. Het is goed om een systeem met verhandelbare spitscredits in te voeren. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

11. Ik denk dat verhandelbare spitscredits de files verminderen. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

12. Ik vind verhandelbare spitscredits goed te begrijpen. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

13. Ik denk dat verhandelbare spitscredits de impact van autogebruik op milieu verminderen. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

14. Ik vind verhandelbare spitscredits een inbreuk op de (mobiliteits)vrijheid. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

15. Ik denk dat verhandelbare spitscredits de privacy van mensen zal schenden. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

16. Ik denk dat ik slechter af ben als verhandelbare spitscredits worden ingevoerd. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

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38%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Verhandelbare spitsrechten (deel 2/3)

17. Ik denk dat verhandelbare spitscredits mij financiële voordelen geven. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

18. Ik denk dat het handelen in spitscredits veel moeite zal kosten. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

19. Ik vind spitscredits erg ingewikkeld. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

20. Het handelen in spitscredits lijkt me leuk. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

21. Ik denk dat het handelen in spitscredits veel tijd zal kosten. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

22. Ik denk dat een systeem met verhandelbare spitscredits technisch te realiseren is. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

23. De overheid is in staat om een systeem met verhandelbare spitscredits in te voeren en te handhaven. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

24. Ik denk dat mensen misbruik zullen maken van een systeem met verhandelbare spitscredits. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

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41%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Verhandelbare spitsrechten (deel 3/3)

25. Hoe eerlijk vindt u spitscredits voor uzelf? *

Heel oneerlijk	Oneerlijk	Niet oneerlijk of eerlijk	Eerlijk	Heel eerlijk
○	○	○	○	○

26. Hoe eerlijk vindt u spitscredits voor anderen? *

Heel oneerlijk	Oneerlijk	Niet eerlijk of oneerlijk	Eerlijk	Heel eerlijk
○	○	○	○	○

27. Hoe effectief denkt u dat spitscredits de files verminderen? *

Helemaal niet effectief	Niet effectief	Onzeker of het effectief is	Effectief	Heel effectief
○	○	○	○	○

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44%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Filemaatregelen

Er zijn verschillende maatregelen mogelijk om file te verminderen. We zijn benieuwd naar uw mening over de verschillende maatregelen. De maatregelen worden eerst kort toegelicht:

- Verhandelbare spitscredits: dit is het systeem dat eerder uitgebreid is toegelicht.
- Spitsheffing: elke automobilist betaalt per rit in de spits een vast bedrag aan de overheid. De opbrengsten worden gebruikt voor verbeteringen binnen het transportsysteem (voor wegen en openbaar vervoer/fiets).
- Kilometerheffing: elke automobilist betaalt per gereden kilometer (zowel binnen als buiten de spits) een vast bedrag aan de overheid. Als een kilometerheffing wordt ingevoerd, wordt de motorrijtuigenbelasting afgeschaft.

28. In hoeverre bent u voor de invoer van verhandelbare spitscredits?
(Eerder kreeg u steeds twee vormen van verhandebare spitscredits systemen te zien. Dit is nu niet het geval. Beantwoord deze vraag met de algemene maatregel zoals toegelicht aan het begin van deze enquête in gedachten, los van de specifieke vorm.) *

	1	2	3	4	5	
Helemaal niet voor	○	○	○	○	○	**Helemaal voor**

29. In hoeverre bent u voor de invoer van een spitsheffing? *

	1	2	3	4	5	
Helemaal niet voor	○	○	○	○	○	**Helemaal voor**

30. In hoeverre bent u voor de invoer van een kilometerheffing? *

	1	2	3	4	5	
Helemaal niet voor	○	○	○	○	○	**Helemaal voor**

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47%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Autogebruik

31. Ik heb persoonlijk last van files. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

32. Files zijn een groot probleem voor de economie. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

33. Files zijn een groot probleem voor het milieu. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

34. Ik vind het belangrijk om zekerheid te hebben over mijn reiskosten. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

35. Ik vind het belangrijk om zekerheid te hebben over mijn reistijden. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

36. Het is makkelijk om alternatieven te nemen (zoals fiets, openbaar vervoer of andere vertrektijden) voor de meeste autoritten in de spits. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

36. Het is makkelijk om alternatieven te nemen (zoals fiets, openbaar vervoer of andere vertrektijden) voor de meeste autoritten in de spits. *

	1	2	3	4	5	
Helemaal mee oneens	○	○	○	○	○	**Helemaal mee eens**

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Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - Persoonskenmerken

37. Wat is uw geslacht? *

- ◯ Man
- ◯ Vrouw
- ◯ Anders

38. Wat is uw geboortejaar? *

Characters used: 0 out of 4.

39. Wat is uw gezinssituatie? *

- ◯ Alleenstaand zonder thuiswonende kinderen
- ◯ Alleenstaand met thuiswonende kinderen
- ◯ Alleenstaand met huisgenoten
- ◯ Samenwonend/getrouwd zonder thuiswonende kinderen
- ◯ Samenwonend/getrouwd met thuiswonende kinderen
- ◯ Anders - namelijk:

40. Wat is het hoogste onderwijsniveau dat u hebt voltooid? *

- ◯ Basisschool of geen diploma
- ◯ Vmbo-kader / vmbo-basis / mbo 1
- ◯ Vmbo gemend / vmbo-t / havo (onderbouw) / vwo (onderbouw)
- ◯ Mbo 2 / mbo 3 / mbo 4

40. Wat is het hoogste onderwijsniveau dat u hebt voltooid? *

- ◯ Basisschool of geen diploma
- ◯ Vmbo-kader / vmbo-basis / mbo 1
- ◯ Vmbo gemend / vmbo-t / havo (onderbouw) / vwo (onderbouw)
- ◯ Mbo 2 / mbo 3 / mbo 4
- ◯ Havo (bovenbouw) / vwo (bovenbouw)
- ◯ Hbo-bachelor / wo-bachelor
- ◯ Hbo-master / wo-master / doctor (PhD)
- ◯ Anders - namelijk:

41. Wat is het meest op u van toepassing wat betreft werksituatie? *

- ◯ Ik heb betaald werk (tot 20 uur per week)
- ◯ Ik heb betaald werk (20 tot 35 uur per week)
- ◯ Ik heb betaald werk (35 uur per week of meer)
- ◯ Ik ben met pensioen
- ◯ Ik ben student / in opleiding
- ◯ Ik heb geen betaald werk
- ◯ Anders - namelijk:

42. Wat is het bruto jaarinkomen van uw huishouden?
(Dat is uw inkomen + die van uw partner als u samenwoont. Het inkomen van thuiswonende kinderen telt niet mee.) *

- ◯ Minder dan 10.000 euro
- ◯ 10.000 - 20.000 euro
- ◯ 20.000 - 30.000 euro
- ◯ 30.000 - 40.000 euro
- ◯ 40.000 - 50.000 euro
- ◯ 50.000 - 60.000 euro
- ◯ 60.000 - 70.000 euro
- ◯ 70.000 - 80.000 euro
- ◯ 80.000 - 90.000 euro
- ◯ 90.000 - 100.000 euro
- ◯ 100.000 euro of meer
- ◯ Dat vertel ik liever niet.

43. Wat is uw postcode? De eerste 4 cijfers zijn voldoende. *

Characters used: 0 (minimum 4).
Characters used: 0 out of 4.

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53%

Enquête verhandelbare spitscredits - Amsterdam

Vragenlijst - De enquête

44. Ik vond de uitleg van verhandelbare spitscredits duidelijk. *

	1	2	3	4	5	
Helemaal mee oneens	◯	◯	◯	◯	◯	**Helemaal mee eens**

45. Ik vond het moeilijk om de keuzes tussen de verhandelbare spitscredit systemen in dit onderzoek te maken. *

	1	2	3	4	5	
Helemaal mee oneens	◯	◯	◯	◯	◯	**Helemaal mee eens**

46. Ik heb informatie gekregen over de nadelen van files in de uitleg over verhandelbare spitscredits (aan het begin van de enquête). *

- ◯ Ja
- ◯ Nee
- ◯ Weet ik niet meer

47. Heeft u nog opmerkingen over verhandelbare spitscredits?

47. Heeft u nog opmerkingen over verhandelbare spitscredits?

48. Heeft u nog vragen of opmerkingen over dit onderzoek?

Back Submit

97%

Enquête verhandelbare spitscredits - Amsterdam

Dank u!

Hartelijk dank voor uw deelname. Voor vragen op opmerkingen kunt u mij mailen: c.vanbergen@student.tudelft.nl. Voor de duidelijkheid: de gemeente Amsterdam is niet van plan om verhandelbare spitscredits in te voeren. Dit was verzonnen voor dit onderzoek.

Chris van Bergen

DEZE PAGINA NIET WEGKLIKKEN: U wordt zo doorgestuurd naar CG research

100%

J

Appendix: Data cleaning

This appendix will discuss the steps that were taken to clean the data in order to prepare it for the data analysis.

- It was checked whether all responses are unique.ch respondent was assigned unique code. It has been checked whether each code only occurs once and therefore respondents did not complete the survey multiple times. Each code only occurred once.
- Incomplete responses were omitted.
- Responses with a completion time below a limit were omitted. has been checked how long it takes to complete the survey if you click through the survey without reading the texts. For surveys with the introduction in text, this was 210 seconds. For surveys with the introduction in a video, this was 360 seconds. Responses with a completion time lower than these were omitted. This filters out respondents who do not take the survey seriously, but purely filled it in for the reward by not reading anything and only answering the questions as quickly as possible. Since deleting data is undesirable in science, the time limit was kept low. Only respondents who really just clicked through the survey were omitted, and respondents who are simply quick were not. 8 responses were omitted based on this time limit.
- The answers to questions in the category 'other, namely:' were checked.spondents could choose the 'Other, namely:...' option for a number of questions in the questionnaire. It was mandatory to enter an answer here. For all these answers, it was examined whether the answer could still be classified under one of the prescribed answer options for that question or not. If a non-existent word was entered, this is marked as missing value.
  - Education
    - HBO propedeuse and WO propedeuse are assigned to the category 'havo (bovenbouw) / vwo (bovenbouw).
    - Post HBO is assigned to the category 'Hbo-master / wo-master / doctor (PhD)'
  - Living situation
    - Students living with their parents are considered a new category.
  - Work situation

        * If respondents indicated multiple situations, for example being retired but also having a few hours of paid work, they were assigned to the category that is (probably) their 'main' situation.
        * Multiple respondents indicated to be incapacitated; they were assigned to the category 'I have no paid work'.
        * Several respondents indicated to be self-employed or to have their own company. They are classified under the paid work category.
    - Main transportation mode
        * One respondent indicated that a truck was his main mode of transport. Since this concerned only one respondent, it was not useful to create a new category. Therefore, it was assigned to the category 'car'.
- Missing values were replaced. order to use the data in Biogeme to estimate choice models, the missing values had to be replaced by the value 99999. There was one missing value for gender, two for work situation and 106 for income.
- It was checked whether all values for birth year were possible and whether all respondents were older than 18. This was both the case.

K

Appendix: Factor analysis

A condition for constructing a summated scale is that the statements are unidimensional. This means that 'they are strongly associated with each other and represent a single concept' (Hair et al., 2013, p. 123). A common way to test this is performing a factor analysis (Ziegler & Hagemann, 2015).

The aim of the factor analysis is to obtain a simple structure solution. This means that each variable has a high loading on only one factor and a low loading on all others (Hair et al., 2013). Various iterations have been made to approach this simple structure solution as well as possible. In addition, the aim was to obtain an interpretable solution. The statements were constructed in such a way that they each belong to an assumed underlying factor (attitude). The aim is therefore to obtain a factor solution in which the statements that belong to one particular factor also load high on one factor.

Principal Axis Factoring (PAF) was used as extraction method since the statements were used to measure latent variables. Rotation of components was applied as this can contribute to obtaining a simple structure. In every iteration, two rotation methods were used to assess which led the most to a simple structure solution. First, the orthogonal rotation Varimax was used. This does not allow a correlation between factors. This ensures that factors are easy to interpret. Moreover, this often gives a clear separation of factors (Hair et al., 2013). However, it is realistic that the dimensions underlying the statements are correlated. Therefore also the the oblique rotation method Direct Oblimin was used, that allows the factors to correlate with each other. Only the solutions that used oblique rotation are shown, as these approached the simple structure solution best in every iteration. Furthermore, factor loadings below 0.30 are not shown, since they are negligible given a sample size bigger than 350 (Hair et al., 2013).

Iteration 1

All statements relating to the following seven attitudes were included in the first factor analysis:

- Perceived effectiveness congestion;
- Perceived complexity;
- Expected personal outcome;
- Expected effort;
- Trust;

- Perceived fairness;
- Problem perception congestion.

The analysis was forced to give a solution with seven factors. The rotated factor-loading matrix is presented in Figure K.1. Already some of the expected structures are visible. The statements related to *Problem perception congestion* cause most problems. The statement *Problem perception congestion (2)* does not load on a single factor. It was therefore decided to remove the statements related to *Problem perception congestion* from the analysis in the second iteration.

	Factor						
	1	2	3	4	5	6	7
Perceived effectiveness congestion (1)	,933						
Perceived effectiveness congestion (2)	,833						
Perceived complexity (1)					,739		
Perceived complexity (2)		,450			-,475		
Expected effort (2)		,628					
Expected effort (1)		,934					
Trust (1)			,769				
Trust (2)			,765				
Perceived fairness (1)				,815			
Perceived fairness (2)				,550			
Expected personal outcome (1)		,312					
Expected personal outcome (2)						,622	
Problem perception congestion (1)							,482
Problem perception congestion (2)							

Figure K.1: Rotated factor-loading matrix with Direct Oblimin rotation - iteration 1

Iteration 2

The analysis was now forced to give a solution with six factors. The rotated factor-loading matrix is presented in Figure K.2. These results are already closer to the simple structure solution. Now the statements related to *Expected personal outcome* pose problems. Both statements load high on a different factor. The statement *Expected personal outcome (1)* loads on the factor on which the statements related to *Expected effort* load. However, this loading of 0.375 is relatively low. It was therefore decided to perform another iteration without the statements related to *Expected personal outcome*.

Iteration 3

The analysis was now forced to give a solution with five factors. The rotated factor-loading matrix is presented in Figure K.3. It is now visible that the structures for all assumed factors have been found as expected: all statements linked to an attitude load together on one factor. So, almost a perfect simple solution is reached. Only the statement *Perceived complexity (2)* loads on two factors: on one factor with statement *Perceived complexity (1)* as expected, but also on the factor together with the two statements related to *Expected effor*t. This could be

	Factor					
	1	2	3	4	5	6
Perceived effectiveness congestion (1)				-,881		
Perceived effectiveness congestion (2)				-,866		
Perceived complexity (1)					,690	
Perceived complexity (2)		,475			-,492	
Expected effort (2)		,724				
Expected effort (1)		,844				
Trust (1)			,713			
Trust (2)			,745			
Perceived fairness (1)	,916					
Perceived fairness (2)	,594					
Expected personal outcome (1)		,375				
Expected personal outcome (2)						-,638

Figure K.2: Rotated factor-loading matrix with Direct Oblimin rotation - iteration 2

expected since there are quite high correlations between these statements (0.538 and 0.606). Ideally there should be no cross-loadings, and it can be decided to omit statements with cross-loadings. However, since *Perceived complexity (2)* also has a high loading on a separate factor together with *Perceived complexity (1)* it was chosen not to omit this statement and to accept the fact that this statement also has a high loading on another factor. The correlation between the factors is presented in Figure K.4.

	Factor				
	1	2	3	4	5
Perceived effectiveness congestion (1)				,945	
Perceived effectiveness congestion (2)				,846	
Perceived complexity (1)					,637
Perceived complexity (2)		,578			-,387
Expected effort (2)		,747			
Expected effort (1)		,859			
Trust (1)			,805		
Trust (2)			,785		
Perceived fairness (1)	,887				
Perceived fairness (2)	,806				

Figure K.3: Rotated factor-loading matrix with Direct Oblimin rotation - iteration 3

Factor	1	2	3	4	5
1	1,000	-,307	,586	,725	,228
2	-,307	1,000	-,436	-,355	-,423
3	,586	-,436	1,000	,659	,358
4	,725	-,355	,659	1,000	,315
5	,228	-,423	,358	,315	1,000

Figure K.4: Factor correlation matrix - iteration 3

L

Appendix: Testing the representativeness of the sample

In this appendix, tests are performed to check whether the sample is representative of the population for the characteristics gender, age, education level and income level.

Chi-squared tests were used to test whether the gender, age, educational level and income distributions in the sample are significantly different from the distributions in the population. Since more than five observations are expected in each category based on the population, Chi-squared tests may be performed. It can be seen from Table L.3, L.6 and L.9 that the Chi-squares are statistically significant. Based on this it can be concluded that the sample is not representative for the population in terms of gender, age and educational level.

L.1 Gender

Table L.1: Gender distribution in Utrecht and Amsterdam 2019. Source: CBS Statline

	Man	**Woman**
Utrecht	172.857	180.009
Amsterdam	427.787	435.178
Total	600.644 (49.4%)	615.187 (50.6%)

Table L.2: Expected values and observed values in the sample for gender

Gender	**Observed amount in sample**	**Expected amount based on population**	**Difference**
Man	213	249	-36
Woman	291	255	36
Total	504	504	

Table L.3: Results Chi-square test gender

Gender	
Chi-square value	101.159
Df	1
p-value	0.001

L.2 Age

Table L.4: Age distribution in Utrecht and Amsterdam 2019. Source: CBS Statline

Age	**Utrecht**	**Amsterdam**	**Percentage**
18-20	8.947	20.426	3.02%
20-25	35.887	67.634	10.66%
25-45	127.867	311.068	45.18%
45-65	74.570	209.828	29.28%
65-80	27.565	84.765	11.56%
80+	9.022	23.215	3.32%

Note: CBS Statline provided the amount of people aged 15-20. Based on this, the amount of people aged 18-20 was estimated and used here.

Table L.5: Expected values and observed values in the sample for age

Age	**Observed amount in sample**	**Expected amount based on population**	**Difference**
18-20	3	15	-12
20-25	28	54	-26
25-45	158	228	-70
45-65	156	148	8
65-80	151	58	93
80+	9	17	-8

Table L.6: Results Chi-square test age

Age	
Chi-square value	200.232
Df	5
p-value	0

L.3 Educational level

Note: The numbers used for Amsterdam are based on people aged 15-74, as no numbers were available for people aged 18+. The numbers used for Utrecht were calculated based on percentages provided in the Volksgezondheidsmonitor Utrecht (2018).

Table L.7: Educational level distribution in Utrecht (2016) and Amsterdam (2017). Sources: Volksgezondheidsmonitor Utrecht (2018) and Gemeente Amsterdam (2018)

Educational level	Utrecht	Amsterdam	Percentage
Low (basisonderwijs, VMBO, MBO-1)	57.731	59.000	16.30%
Medium (MBO 2-4, HAVO, VWO)	71.477	123.000	27.10%
High (HBO/WO)	142.954	263.000	56.60%

Table L.8: Expected values and observed values in the sample for educational level

Educational level	Observed amount in sample	Expected amount based on population	Difference
Low (basisonderwijs, VMBO, MBO-1)	64	82	-18
Medium (MBO 2-4, HAVO, VWO)	169	137	32
High (HBO/WO)	272	286	-14

Table L.9: Results Chi-square test educational level

Educational level	
Chi-square value	12.295
Df	2
p-value	0.002

L.4 Income

106 of the 505 respondents indicated that they did not want to what category of income they belonged. It is unknown whether people of certain income categories more often decide not to share this information. For example, it is possible that many people with a high income do not want to share their income category. Due to this and the high amount of missing values, it is not possible to determine whether the sample is representative for the population in terms of income.

M

Appendix: The fixed characteristics of the TPC system in this research

As discussed in Chapter 4, several designs of a TPC system are possible. Therefore it still had to be decided what the TPC system is this study entails. A choice has therefore been made for a number of design variables, and these choices together form the fixed characteristics of the TPC system that is being investigated in this study. An overview of the fixed design variables is given in Table M.1. This appendix substantiates the choices. The choices were made based on conversations with Lizet Krabbenborg and the consulted road pricing scientists.

Geographic area of applicability of credits
In order to make the choice task as realistic as possible, an area has been chosen for which it is realistic that TPC would be introduced there. It is expected that if a system like TPC will ever be introduced, this will apply to certain areas with a lot of traffic jams and not to the entire Netherlands. Therefore, all highways and N roads in the municipality of Amsterdam were chosen as the geographic area to which TPC would apply. Designating a specific region makes the choice task for respondents more realistic. On the other hand, it is not too detailed, for example by naming exact road numbers. This prevents respondents from basing their opinion too much on the exact area, while we are interested in their opinion about TPC in general. For example, it is undesirable for respondents to check whether there are routes to avoid the area where credits are needed. The survey was also distributed to residents of Utrecht and in that version the TPC system applies to all N roads and highways in the municipality of Utrecht.

Peak and off-peak periods
07:00 - 09:15 and 16:00 - 18:15 are considered peak periods. In reality there are small variations in what are considered peak periods. However, these variations are small, and therefore it does not seem useful to include this as an attribute in the stated choice experiment. However, in order for the choice task to be realistic for respondents, it must be clear what the peak periods are. Therefore it is a fixed characteristic.

Target group of credits
The more traffic is targeted by the TPC system, the more control there is over the amount of traffic that is allowed at a certain location during peak hours. This increases the effectiveness of the TPC system. It has therefore been decided to exclude only trucks and emergency services from the TPC system in this research. The TPC system thus applies to all passenger cars.

Method to create differentiation within the credit scheme
The TPC system that is the subject of this research has time-place specific credits. The reason for this choice is that this keeps the instrument simple. Keeping the instrument simple is important, since respondent are probably not familiar with it. When time-place dependent credits would have been chosen, there would be time- and place dependent credit rates. Using such rates would make the system more complicated, without this really being necessary for the operation of the system.

Since time-place specific credits are chosen, the degree of place-specificity and time-specificity of credits must be defined. The place-specificity of the credit is fixed in this study: one credit will apply for the entire geographical area. This is again the simplest option, but it is also realistic. If TPC is introduced in a limited-size region, it is unlikely that different geographical zones with their own credits would be distinguished within that region. This would make trading of credits very complex and thus reduce the practical feasibility of the system. The period of validity of credits, the time-specificity, is not a fixed characteristic. As discussed there might be an important trade-off between the effectiveness of the system and the effort for users. It is expected that if credits are more specific in terms of time, they are also more effective at reducing congestion. Note that it is not certain that this is the case; it is an expectation. However, if it is the case it would be interesting to know what public preferences are regarding the time-specificity of credits.

Unit of credits
A fixed characteristic of the TPC system is that credits represent a trip during peak hours.

Way of allocating credits
The introduction of tradable driving credit systems for mobility management is being investigated because it is expected that such measures will have relatively high acceptability compared to other road pricing measures. The principle of grandfathering in TPC is an important cause of this (Raux, 2007). Grandfathering, allocating credits for free, is therefore considered a fixed characteristic of the TPC system in this study.

Trading parties
The fact that no money flows to the government is mentioned as an advantage of tradable driving credit systems. This characteristic partly causes the expectation that such measures will have relatively high acceptability compared to other road pricing measures. It is therefore considered a fixed characteristic that credits are not sold back to the scheme operator, but that trading of credits takes place between individuals. The method proposed by Brands et al. (2019) where people trade via an intermediary is chosen. People can buy and sell credits at a trading platform. It will also be possible to buy credits in stores.

Market operation
In almost all literature on tradable driving credits, the price of credits is determined by the market. Economically speaking, this is more efficient than using a fixed price. It is therefore chosen as a fixed characteristic of TPC that the price of a credit is determined by the market.

Whether there is a maximum credit price is not selected as an attribute for the stated choice experiment. We do however want to prevent respondents from making assumptions about this, since they can be afraid that the credit price may become excessively high. I expect the Dutch government to apply a maximum credit price to ensure that rush-hour driving remains affordable to a certain extent. That is why it has been decided to assume a maximum credit price. The estimate of the maximum price is €6,-. This estimate was submitted to Erik Verhoef and he confirmed that this was a realistic estimate.

Policy for foreign vehicles
It was decided that foreign vehicles always have to buy credits to drive during peak hours. If

these vehicles do not require credits, this is probably considered unfair and the system is less effective in reducing congestion as more cars can drive than credits are issued.

Monitoring
It is assumed a fixed characteristic of TPC that people have a personal account to manage their credits and that there is a system that ensures that credits are automatically deducted from your account when making a drive during peak hours. The specific technology that makes this possible is not taken into consideration. The reason for this is that the explanation of different technologies and their implications will be fairly complex. Moreover, it is expected that for people to form their opinion it is enough to explain how the system would work, without specifying exactly which technological means are being used.

Enforcement
If a person from the target group does not have a valid credit for a rush-hour ride, he receives a notification to purchase a credit for that drive and he has a few hours to do so. If he does not purchase a credit, the system automatically buys a credit for him at the market price, plus transaction costs. These transaction costs should discourage people from driving without credits. It has been decided not to impose a fine because it is expected that this will decrease the acceptance of people. Moreover, road pricing experts expected that it is not necessary to impose a fine, but that the letting people pay transaction costs is enough incentive for them to purchase credits themselves when necessary. Erik Verhoef estimated the transaction costs at €1,- per transaction.

Purchase limits
Based on discussions with road pricing scientists, it was decided to set a purchase limit. This must prevent speculation. Without a purchase limit, speculation is expected to be an important concern of people. Since the attribute is primarily intended to prevent speculation, it has been decided to set the purchase limit equal to the number of credits that you could use as a person. For example, you can use a maximum of 10 credits a week. Depending on how many credits someone has initially received, it can be determined how many credits a person can purchase.

Credit scheme operator
It may be relevant for respondents to know who introduces and manages the TPC system. The assumption in this study is that this is a government agency.

Table M.1: Summary of characteristics TPC system in this study

Design variable	**Choice**
Geographic area of applicability of credits	Amsterdam or Utrecht
Peak and off-peak periods	Peak period: weekdays from 07:00 - 09:15 and from 16:00 - 18:15
Target group of credits	All passenger vehicles
Method to create differentiation within the credit scheme	Time-place specific credits
Units of credits	Trip
Way of allocating credits	Grandfathering: all available credits distributed free of charge
Trading parties	Trading between individual participants on a trading platform
Monitoring	Personal account to manage credits & system that automatically deducts credits when necessary
Enforcement	First a notification; if necessary credit is automatically bought, additional transaction costs
Market operation	Market determines the price - price ceiling of €6,-
Policy for foreign vehicles	Foreign vehicles always have to buy credits to drive during peak hours

N

Appendix: Testing assumptions regression analysis

The assumptions for a regression analysis are the following:

1. The independent variable is continuous
2. Independent observations
3. Linear relationship between independent variables and dependent variable
4. Homoscedasticity of the errors
5. Normality of the error distribution

The independent variables are all measured on a Likert scale and considered as interval variables. Therefore, the first condition is met. The observations are independent, so also the second condition is met. The last three assumptions will now be tested for the individual regression models.

N.1 Regression model 1: Support TPC

Since dummy variables are used for educational level and gender, only for the variable age it must be tested whether it has a linear relationship with support for TPC. A scatter plot is used to visualize the relationship in Figure N.1. This indicates a linear relationship between age and support for TPC. Furthermore, Figure N.2 shows that the residuals have a fairly equal variance for all predicted values of the dependent variable support TPC. For small values of the predicted support values, the residuals are slightly more positive than the residuals for the high values of the predicted support values. This could indicate a non-linear relationship with one of the independent variables. A quadratic component of the variable age was added to the model to see whether a quadratic relationship is present. This was however not the case. Based on this it is assumed that condition four is reasonably met. Finally, Figure N.3 tests the fifth assumption. The data reasonably follows the normal distribution.

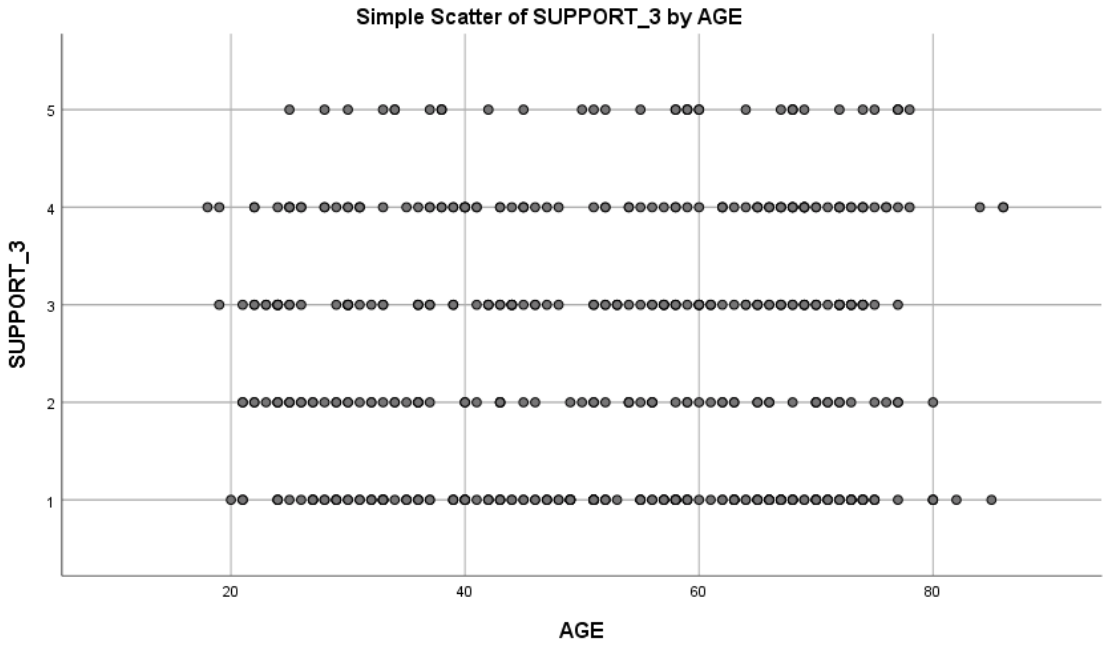

Figure N.1: Scatterplot age – support TPC

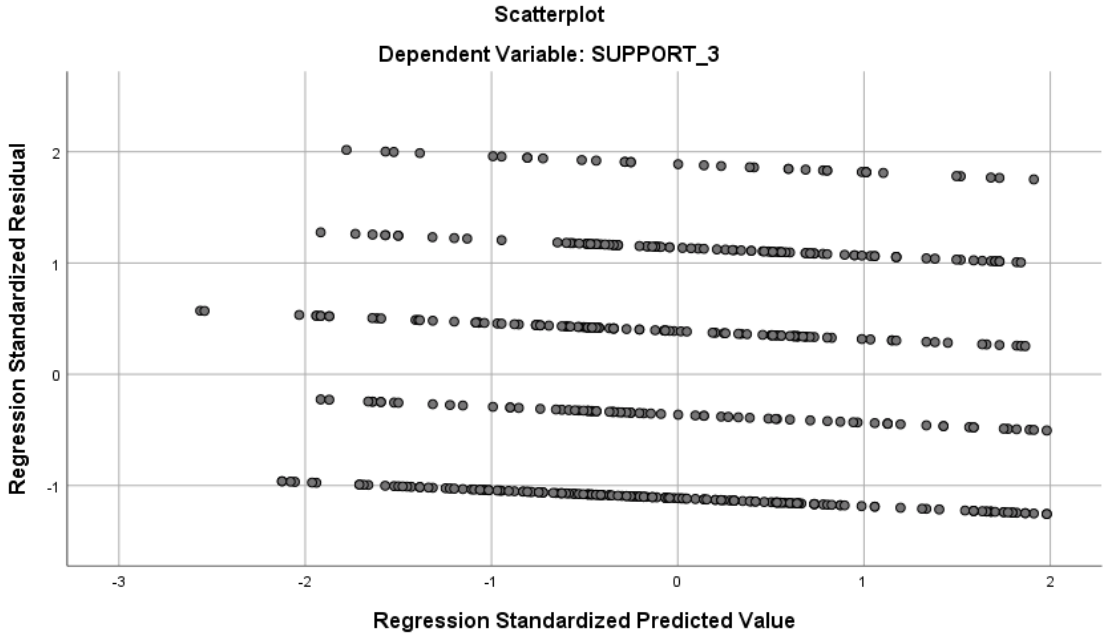

Figure N.2: Scatterplot residuals regression model 1

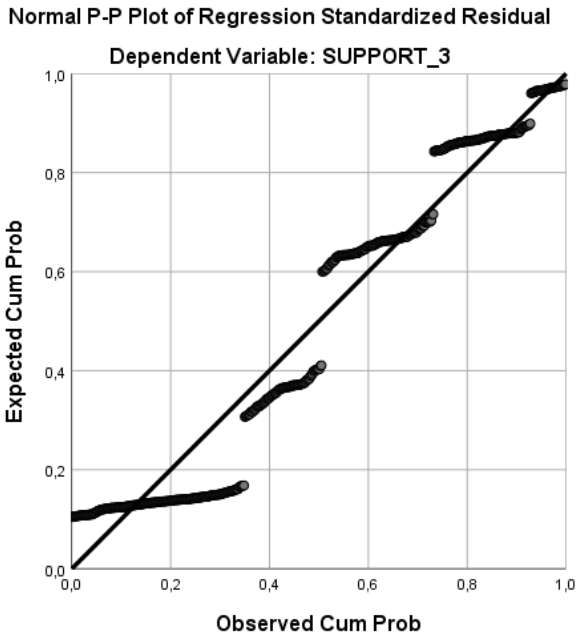

Figure N.3: Normal probability plot of standardized residuals regression model 1

N.2 Regression model 2: Support congestion charge

Again it must only be tested whether age has a linear relationship with support for a congestion charge. A scatter plot is used to visualize the relationship in Figure N.4. This indicates a linear relationship between age and support for a congestion charge. Furthermore, Figure N.5 shows that again for small values of the predicted support values, the residuals are slightly more positive than the residuals for the high values of the predicted support values. Therefore again it was tested whether there is a quadratic relationship between age and support, but this was not the case. Since the residuals have a fairly equal variance for all predicted values of the dependent variable support congestion charge, it is assumed that condition four is also met. Finally, Figure N.6 tests the fifth assumption. The data reasonably follows the normal distribution.

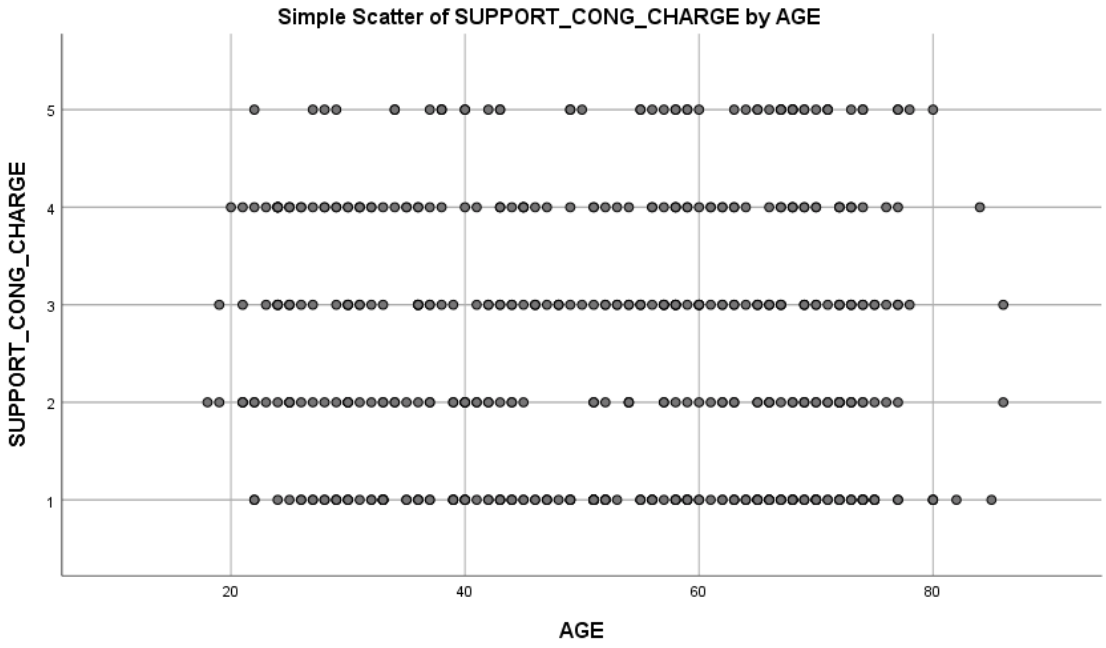

Figure N.4: Scatterplot age – support congestion charge

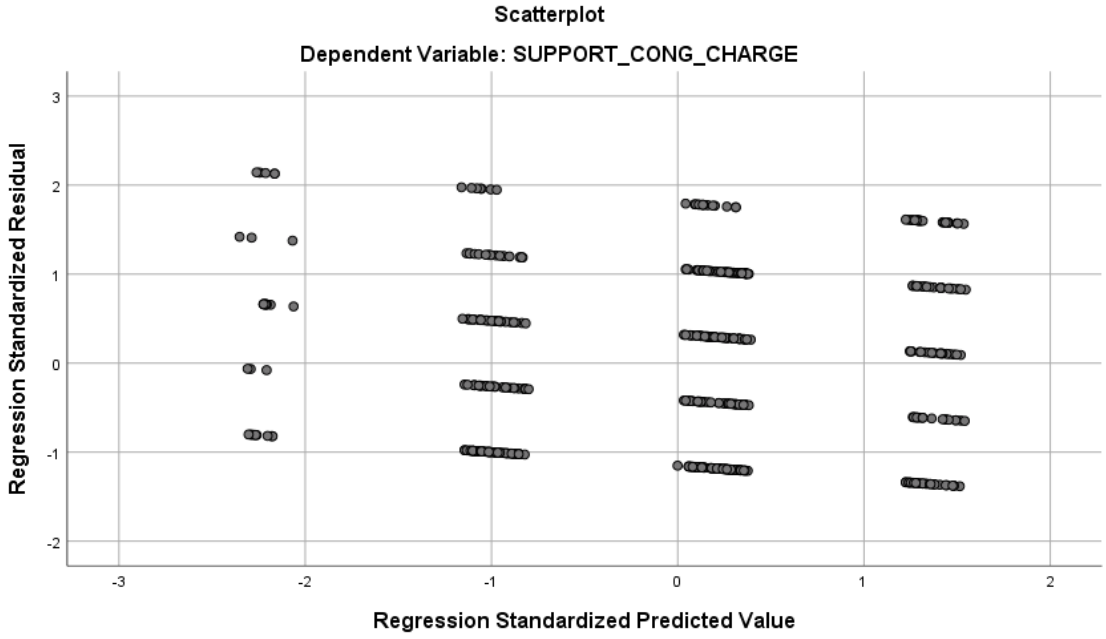

Figure N.5: Scatterplot residuals regression model 2

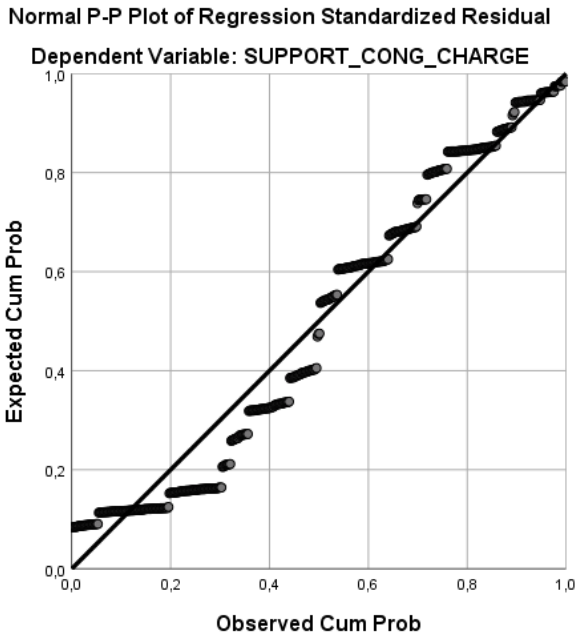

Figure N.6: Normal probability plot of standardized residuals regression model 2

N.3 Regression model 3: Support kilometer charge

Based on the same tests as for the other two regression models, it can be concluded that the assumptions for the regression analysis are reasonably met again.

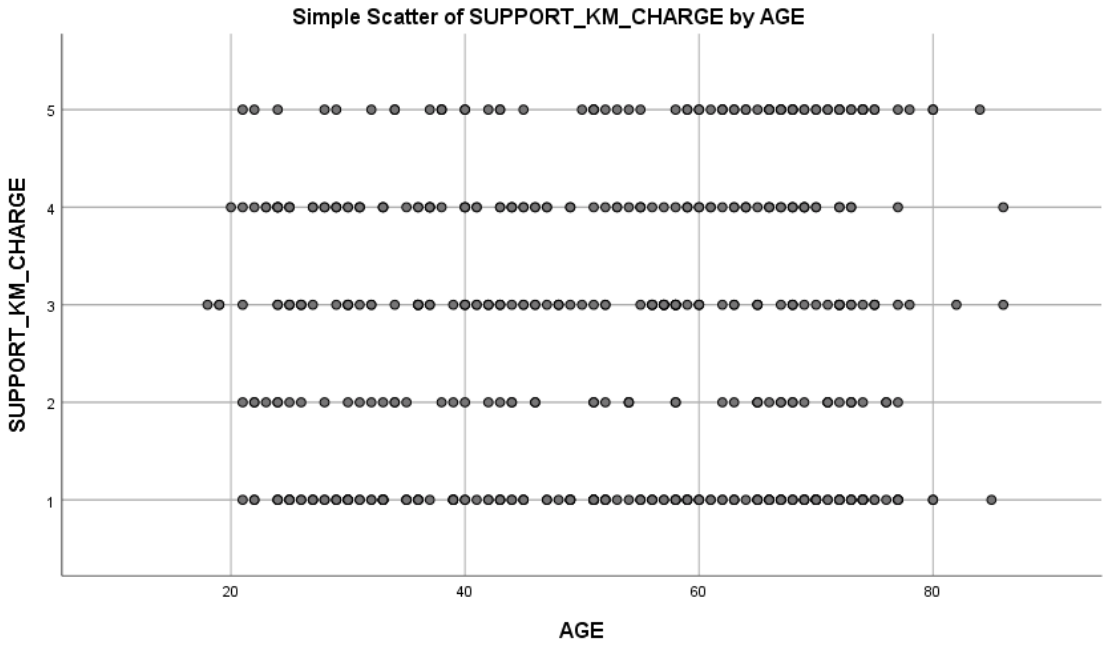

Figure N.7: Scatterplot age – support kilometer charge

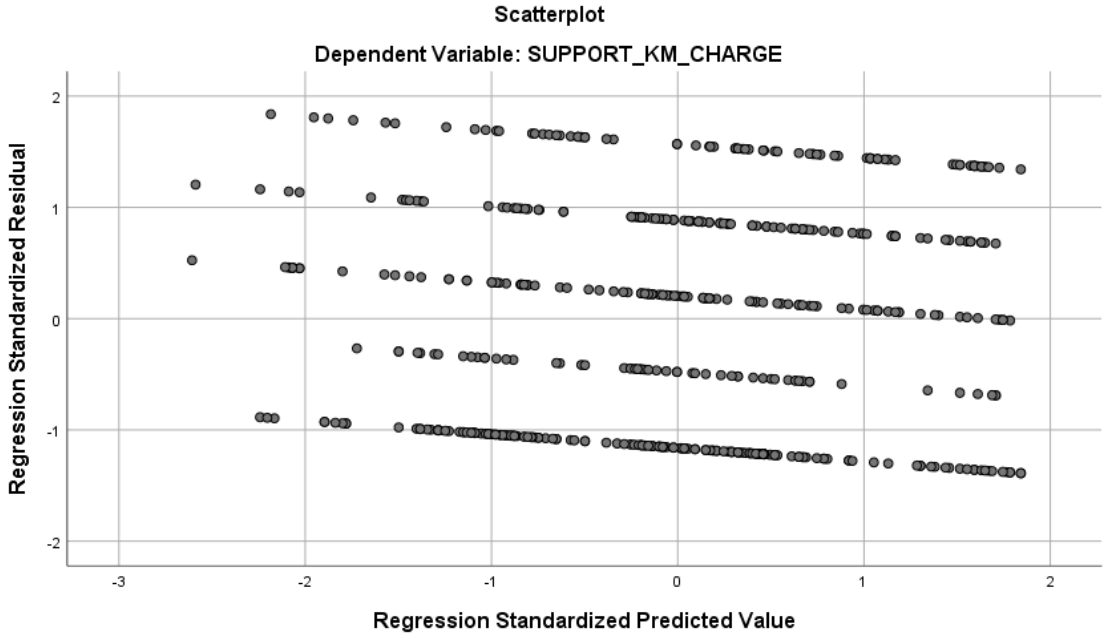

Figure N.8: Scatterplot residuals regression model 3

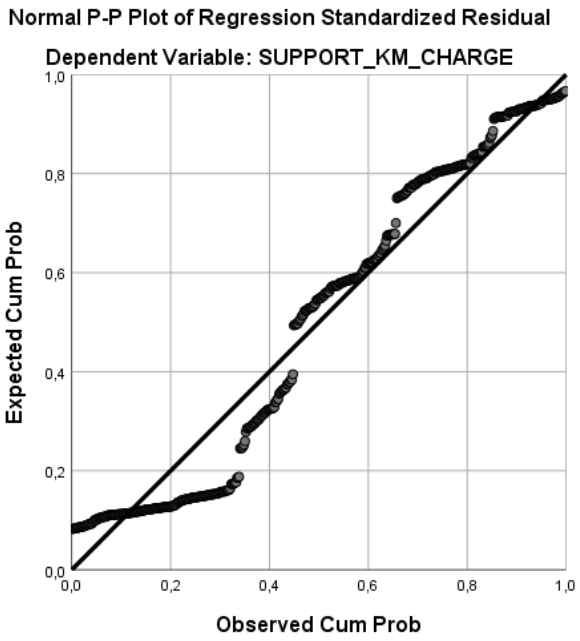

Figure N.9: Normal probability plot of standardized residuals regression model 3