Ioannis Kosmidis

Distributional Fairness in Road Safety Policies

A Discrete Choice Approach to Explore Citizens’ Preferences on the Distribution of the Effects of Road Safety Policies

TU Delft

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A Discrete Choice Approach to Explore the Preferences of Citizens on the Distribution of the Effects of Road Safety Policies

Master Thesis Report

By

Ioannis Kosmidis

in partial fulfilment of the requirements for the degree of

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TU Delft

Preface

Ever since I can remember, I find myself being intrigued by the everyday wicked problems, ethical dilemmas and philosophical questions that in most cases result in an interesting discussion and a constructive exchange of opinions and ideas. From the first year of my master studies at the Delft University of Technology I tried to find research topics that would provide me with a similar feeling. This is when I discovered two of my favourite fields of interest related to transport. The first one is the social aspect of transport polices and projects, and more specifically how different groups of people are affected, while the second one is that of road safety.

During my studies, I decided to enrich my knowledge on these two topics by pursuing an internship on two Dutch research institutions. For two months I had the opportunity to explore the social aspects and equity issues of transport projects and policies as a research intern at the Kennisinstituut voor Mobiliteitsbeleid (Netherlands Institute for Transport Policy Analysis). Later, I was part of a group that conducted a road safety study for SWOV (Institute for Road Safety Research in the Netherlands) for four months. One of the challenges of that study was to propose a solution that is in accordance to the needs and preferences of all different road users and stakeholder groups, which gave a social side to it.

After getting a first practical experience in both my fields of interest, I decided to include both of them in my master thesis. This master thesis marks the end of my two-year journey as a master student of the Delft University of Technology. I was engaged in conducting and writing this study from April to November 2019. I found writing this thesis really inspiring and fulfilling and I hope that it attracts the interest of more academics to explore this topic more extensively.

Ioannis Kosmidis

Delft, November 2019

Acknowledgements

First and foremost, I would like to express my gratitude to my thesis committee. More specifically, I would like to thank Prof.dr. Bert van Wee for giving me the opportunity to explore the topic of fairness in road safety policies and for showing me his trust by giving me the freedom to frame my thesis topic to follow my desired path. Moreover, I am truly thankful to Dr. Eric Molin, for his excellent supervision and support during the study and especially on the experimental part. I am also grateful to Dr.ir. Haneen Farah for her constructive criticism on my work and her practical suggestions for improvement. I would also like to acknowledge and extend my gratitude to Mehrnaz Asadi for her help and guidance during the initial stages of this study. The draft of her PhD proposal document has been a great inspiration to my study.

At this point, I would like to thank each and every one of my friends, whose support has been enormous in this two-year journey. Finally, I owe my deep gratitude to my family, for their constant support and encouragement over the past two years. Without them I would not be here today, therefore I am eternally indebted. The past few years have been quite challenging for our family, but their strength and courage through tough times has been an inspiration to me during my studies.

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List of Abbreviations

ADAS	Advanced Driver-Assistance Systems
CBA	Cost Benefit Analysis
EU	European Union
HII	Hierarchical Information Integration
LPTV	Landelijk Parket Team Verkeer / The National Traffic Prosecution Team
LRS	Loglikelihood Ratio Statistic
ML	Mixed Logit / Mixed Multinomial Logit
MNL	Multinomial Logit
QALY	Quality Adjusted Life Years
RQ	Research question
RUM	Random Utility Maximization
SQ	Sub-question
SWOV	Stichting Wetenschappelijk Onderzoek Verkeersveiligheid / Institute for Road Safety Research
VSL	Value of Statistical Life
VVN	Veilig Verkeer Nederland / Safe Traffic Netherlands
WTA	Willingness to Accept
WTP	Willingness to Pay

Executive Summary

To define a policy or policy program as “good”, it does not only have to be effective, but also efficient and fair. Policies are often rejected, even though they are cost-efficient, due to low public acceptability which results from social aspects of the policies, e.g. how fair people think that a policy is. Road safety is a field with huge social aspects and ethical dilemmas (e.g. whether it is fair to save a car user or a vulnerable road user), but there is little understanding on how people perceive them, in order to be able to define a road safety policy as fair. Therefore, this study aims to explore the preferences of citizens regarding fairness considerations related to the distribution of the effects of road safety policies.

To achieve this the Discrete Choice Approach is followed, using Stated Preference data. This requires conducting a Stated Preference experiment where participants specify their choices over different hypothetical road safety policy alternatives that include fairness considerations, among other policy characteristics. However, in order to create those hypothetical scenarios, fairness needs to be defined and measured. This is done again with the Stated Preference method, where people evaluate road safety policies on their fairness based on some criteria or characteristics that was presented to them. Before conducting the Stated Preference experiment, it is important to conduct a preliminary research.

The aim of this preliminary research is to obtain all the necessary primary data, and more specifically the attributes, that will be used in the stated preference experiment. This preliminary method consists of two parts. The first part included a focus group discussion, while the second part individual exploratory interviews. The main attributes that were identified in the preliminary research and were later included in the first part of the stated preference experiment, which is the Distributional Fairness Perception experiment, are divided in three categories as follows.

Distribution of road safety benefits:

- Spatial distribution
- Distribution to the different road user types
- Distribution to the different age groups

Distribution of monetary costs:

- Distribution to the different road user types
- Distribution to the different income groups

Distribution of non-monetary negative externalities:

- Distribution to the different road user types
- Distribution to the different age groups

Moreover, the aggregate magnitude of those effects together with the perception of distributional fairness have been included in the second part of the Stated Preference experiment, which is the Road Safety Policy Choice experiment.

The Stated Preference experiment took place from the 13th of September to the 5th of October 2019. From this process the responses for a sample of 64 participants have been gathered. These responses have been then analysed in order to estimate, firstly, the Linear Regression models for the Distributional Fairness Perception experiment, and secondly the Multinomial Logit models for the Road Safety Policy Choice experiment. The results of those models are then used in order to answer the main research question of this study.

In general, this study has shown that the Discrete Choice Approach can actually give some insight to moral dilemmas related to road safety as it is suggested by the literature. The main outcome of this research is that looking only at the aggregate effects, such as the monetary costs, the effectiveness or the non-monetary negative externalities (travel time increase, reduction of mobility) of a road safety policy can be often misleading. The distribution of those effects influences the public acceptance of the policies. People are willing to accept a policy that is more expensive or results in larger negative effects if they think it is more fair, but only up to a specific extent. However, they are not willing to trade the positive effects, such as the effectiveness, of a road safety policy for an increase on fairness perception.

Finally, two practical recommendations are given to policymakers in order to help them make their road safety policy interventions more efficient. The first is to promote the social dialogue between stakeholders to ensure that their needs and preferences are taken into account both in the design and in the decision-making process. The second one is to incorporate fairness considerations in the decision-making process with a separate equity analysis that focuses on the distribution of the effects of the considered road safety policy alternatives to the different groups of people or stakeholder groups.

1. Introduction

1.1. Problem Statement

In 2018, the Institute for Road Safety Research in the Netherlands (SWOV) published the third version of the Sustainable Safety vision. The Sustainable Safety vision has been firstly introduced by SWOV during the 1990s. The Sustainable Safety vision aims in preventing crashes from occurring as much as possible, and if not then prevent severe injuries. According to Weijermars and Wegman (2011) all the measures followed in the first 10 years of the Sustainable Safety vision were concluded to be cost-effective. However, in order to define a policy or policy program as “good”, it does not only have to be effective, but also efficient and fair (van Wee, 2011). Generally, policies are often rejected, even though they are cost-efficient, due to low public acceptability which results from social aspects of the policies, e.g. how fair people think that a policy is (Noordegraaf, Annema, & van Wee, 2014; van Wee, 2010).

Fairness (can also be found as equity or justice) is an important element in transport safety policies too, and it needs to be well incorporated in their appraisal. However, there are some issues in evaluating fairness of transport policies. As it is discussed in more detail in *Section 2.6*, fairness is not a physical and observable aspect of a policy. Therefore, there is no widely acceptable definition of what fairness is, nor a specific way to measure it. Consequently, it is hard to know how people perceive fairness of road safety policies and to what extent that perception of fairness plays an important role compared to the other aspects of the policy. Thus, it is hard for policymakers to substantiate their choice to reject a cost-efficient policy that they find unfair. There is, however, a wide range of theories and perspectives in the literature that could be useful in exploring fairness issues of road safety policies. Those theories are called equity theories or theories of justice (see *Section 2.6*).

1.2. Research Scope and Research Questions

This study aims to explore the preferences of citizens regarding fairness issues related to the distribution of the effects of road safety policies in order to provide policy recommendations that will consequently result in promoting more fair road safety policies. This means that the scope of the study will be limited to examine only fairness from the aspect of distributive justice (or distributional fairness from now on). Other ethical perspectives (see *Section 2.6*), such as criminalization, paternalism, privacy, responsibility or procedural justice are beyond the scope of this study.

In general, distributional fairness describes how a society should allocate its resources or goods to individuals or groups with competing needs or claims (Deutsch, 1975). As regards road safety policymaking, distributional fairness can be related to the way that the effects of road safety policies, both positive and negative, are distributed to different individuals, groups or regions. By understanding how people perceive distributional fairness, which factors influence this perception and how they trade-off distributional fairness against other aspects of road safety policies, policymakers will be able to opt for a road safety policy option that will probably have the highest acceptability by the public.

In other words, to achieve the main research goal two main knowledge gaps need to be filled. Firstly, it is necessary to identify which aspects influence citizens' perception of distributional fairness of road safety policies, and secondly to observe how this perceived distributional fairness is traded-off against other aspects of those policies (such as reduction of fatalities or cost). To achieve the aim of this study the following Research Question has been formulated.

To what extent are citizens willing to trade-off distributional fairness against other aspects of road safety policies?

However, in order to answer adequately this Research Question, it is necessary to fill several knowledge gaps. In order to fill those knowledge gaps, several sub-questions are necessary to be formulated. First of all, it would be important to identify the equity theories that exist in literature and could be applied in a study related to road safety policies. This way, different definitions of fairness can be formulated and later be used in the study. Moreover, it is important to identify the factors or aspects of the road safety policies that influence the distributional fairness perception of citizens. That way the important attributes of those policies will be formulated before attempting to explore the trade-offs between them. The formulated sub-questions are as follows.

SQ 1: *Which equity theories can be applicable in road safety policies?*

SQ 2a: *Which factors influence citizens' perception of distributional fairness in road safety policies?*

SQ 2b: *To what extent do these factors influence citizens' perception of distributional fairness in road safety policies?*

SQ 3: *To what extent does the perceived distributional fairness influence the preference of citizens over different road safety policy options that have fairness implications compared to other aspects of those policy options?*

1.3. Research Approach

This study's objective is to explore the preferences of people on the topic, which means that it aims to describe people's actual behaviour, rather than describe how they should behave. This means that a descriptive approach needs to be followed. One such approach is the Discrete Choice Approach, which has been chosen to be followed in this study.

Moreover, this study will explore the preferences of people from the perspective of the citizen and not as a consumer. This means that the experiments which will be conducted need to be formulated based on this perspective. Hence, a focus on the aggregate benefits and costs to the society will be given, and not to impacts of the road safety policies on the personal level.

By following the Discrete Choice Approach using stated preference data, the trade-offs that people make during their choices are observed empirically. This requires conducting a stated preference experiment where participants specify their choices over different hypothetical road safety policy options that include fairness considerations, among other policy characteristics. This provides with an indication of the trade-off of fairness with the rest of the policy aspects. However, in order to create those hypothetical scenarios, fairness needs to be defined and measured first.

This will be done again with the Stated Preference method, but this time people will be asked to rate policies on their level of fairness based on some factors or characteristics that are presented to them. This way the influence of those characteristics on the perception of distributional fairness can be measured. However, before that a preliminary research needs to be conducted in order to identify those characteristics and factors that influence the perception of distributional fairness.

In the next section the methodological steps that will be followed in this study based on the research approach that is presented here, and the Research question and the sub-questions that have been formulated in *Section 1.2*.

1.4. Methodological Steps

The Discrete Choice Approach, as already mentioned before, will be used in order to answer the main research question, and thus achieve the main research objective. However, in order to reach that point, the sub-questions that have been formulated in *Section 1.2* need to be answered first. As discussed above, each sub-question requires a different approach. In this section a brief discussion on the methodological steps that need to be followed in order to answer each sub-question and consequently the main research question is presented (see Figure 1). However, all methods that are followed are going to be discussed analytically in *Chapter 3*.

First and foremost, SQ 1 is related to the connection of the ethical aspects and theories with the field of road safety policymaking. This will help to identify the equity theories and types that can be possibly applied in the field of road safety. This will be achieved via the literature review, presented in *Chapter 2*, where the relevant theories and equity types are presented (*Section 2.6*). Those theories will be later linked to the relevant factors and aspects that need to be identified, in order to answer SQ 2a, and will be used to design the main experimental method. To identify those aspects related to SQ 2a, a preliminary research is required. As will be discussed explicitly in *Section 3.1*, two methods have been chosen to be followed. Those two methods are a focus group discussion and several individual interviews.

By obtaining the necessary information it will become possible to prepare and design the main experimental method that is used for this study and will help to answer the remaining sub-questions (SQ 2b and SQ 3). The main experimental method, as will be discussed in more detail in *Section 3.2*, will consist of two distinct parts that are performed simultaneously. The first part is a rating experiment, where people are asked to score different road safety policies on their level of distributional fairness, while the second one is a stated choice experiment, where people are asked to choose over different road safety policy options with different characteristics (one of them being the distributional fairness perception).

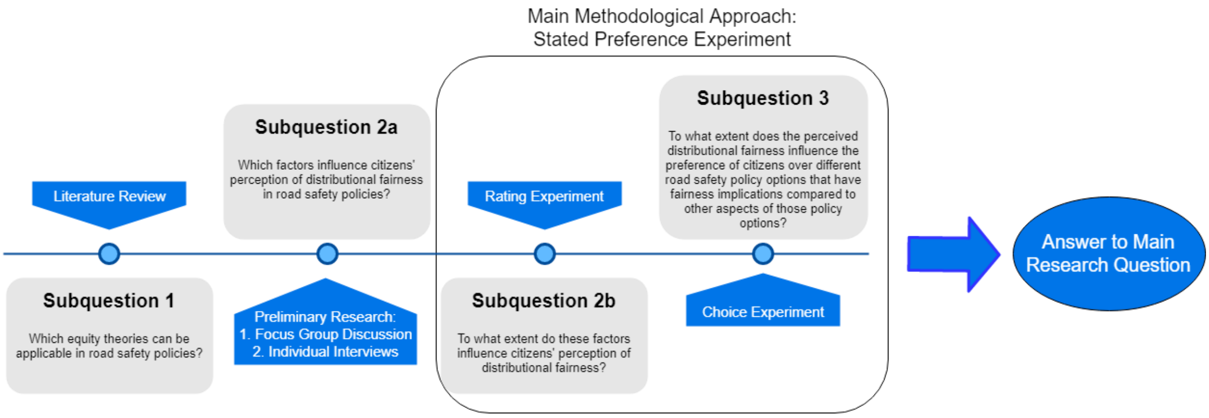


Figure 1 – Methodological steps to answer the main research question

Each experiment is used to answer different sub-questions. As can be seen in the figure below, the rating experiment is used to answer SQ2b, while the choice experiment is used to answer SQ3 and consequently answers the main Research Question. More details for each of the research methods that will be followed in this study can be found in *Chapter 3*.

1.5. Thesis Outline

This thesis report begins with an introductory chapter (*Chapter 1* – Introduction). The aim of this chapter is to make the reader familiar with the topic of this thesis, the aim of this study, the research approach, the methodological steps and the structure of this report.

The following chapter (*Chapter 2* – Literature Review on Ethical Aspects of Road Safety Policies) presents an overview of the relevant literature in order to provide the reader with all the necessary background information to follow the storyline of this thesis. An overview related to road safety policies and the moral dilemmas included in them is presented first, together with some theoretical background information related to the fairness in the distribution of effects. Finally, the contribution of using the discrete choice approach in understanding people's preferences when confronted with moral dilemmas is discussed.

In the third chapter (*Chapter 3* – Methodological Approach) the research approach is described in more detail. Firstly, the exploratory research methods for the primary data collection are described, and secondly the main experimental method, i.e. the stated preference experiment.

In the fourth chapter (*Chapter 4* – Preliminary Research) the process of designing and conducting the Focus Group Session and the Individual Exploratory Research Interviews is presented. Also, the main findings of this preliminary research, that are going to be used for the design of the Stated Preference Experiment, will be discussed.

The fifth chapter (*Chapter 5* – Experimental Design) describes the process of generating both the Distributional Fairness Perception and Road Safety Policy Choice Experimental Designs for the construction of the survey questionnaire.

In the sixth chapter (*Chapter 6* – Data Analysis) the analysis of the data that were gathered from the Stated Preference experiment is presented. The data analysis consists of descriptive statistics and the outcomes of the model estimations related to the two parts of the experiment.

The seventh chapter (*Chapter 7* – Results) presents an attempt to answer the Research Question and the sub-questions that have been formulated in the *Introduction*, based on the outcomes of the models that have been estimated in the previous chapter.

Finally, the eighth chapter (*Chapter 8* – Conclusions, Discussion and Recommendations) presents the conclusions of this study, discusses its limitations, and finally provides relevant recommendations for future steps and research studies that need to be considered, and practical recommendations to assist policymakers in the decision-making process.

2. Literature Review on Ethical Aspects of Road Safety Policies

In this chapter, an overview of the relevant literature is presented in order to provide the reader with all the necessary background information to follow the storyline of this thesis. Firstly, a short introduction is provided into the importance of road safety and the road safety policies (*Section 2.1*), followed by a summary of the most important milestones in the field of road safety policymaking in the European Union and the Netherlands (*Section 2.2* and *Section 2.3*), in order to make the reader familiar to the topic of this study.

Moreover, in *Section 2.4* the moral dilemmas that exist in the field of road safety are presented, together with a short summary of the criticism on the current practices in evaluating roads safety polices follows (*Section 2.5*) in order to make clear the importance of including fairness considerations in road safety policymaking. After that an introduction to the concept of fairness is provided (*Section 2.6*), by describing the equity types and relevant equity theories that could be potentially applied in road safety policies, and how scholars have attempted to include those in similar transport fields (*Section 2.7*). Finally, the potential advantages of using the discrete choice approach to explore the moral dilemmas (*Section 2.8*), and how this motivated the current study to apply it in the field of road safety policymaking is described (*Section 2.9*).

2.1. The Importance of Road Safety and Road Safety Policies

Participating in road traffic can be considered a task that includes many inherent risks and dangers. In general, every person that participates in traffic is exposed to certain risks that are inherent in road traffic and reduce the level of safety. The risks in road traffic are considerably higher than in any other mode of transport (van Wee, Annema, & Banister, 2013). The fundamental risk factors that exist in a road transport environment are, according to van Wee, Annema, and Banister (2013), the speed and mass of the vehicles, the speed and mass differences between vehicles, and the nature of the human body that constitutes it vulnerable. It is thus understood that everyone is exposed to the possibility of getting involved into a road traffic accident.

Every year around 1.24 million people lose their life in a road traffic accident, making it the second most frequent death cause in the world (World Health Organization, 2014). A surprising 50% of those deaths include vulnerable roads users, i.e. pedestrians, cyclists and motorcyclists, while in urban areas of the EU this percentage has reached 70% for the period 2015-2017 (European Transport Safety Council, 2019). Moreover, road traffic accidents are the number one cause of death among young people, aging from 15 to 29 years (World Health Organization, 2014). Road traffic accidents, though, are more than just a negative effect of road traffic. As van Wee et al. (2013) mention "*road accidents constitute unexpected personal tragedies that can happen to everyone, anytime, and anywhere*".

However, road accidents do not only have a negative impact on individuals, but also in communities and countries. Thus, road traffic accidents can be also framed in other ways, such as a health problem, a societal issue, or an economic issue. They burden health care systems with high costs, occupy scarce hospital beds, consume resources and result in significant losses of productivity and prosperity (World Health Organization, 2014). Road traffic crashes cost on average 3% of a country's gross national product (World Health Organization, 2014). Moreover, there are indirect costs related to road traffic accidents, such as loss of productivity, vehicle and property damage, and reduced quality of life.

For all the aforementioned reasons, governments around the world strive to reduce the number of fatalities and severe injuries as much as possible, by introducing road safety policies. In general, Elvik (2009) identifies four main categories of road safety policy measures that governments can implement. Those are the road-related safety measures, the vehicle-related safety measures, the enforcement-related safety measures, and finally the road user-related safety measures.

The first category, i.e. road-related safety measures, includes measures such as road lighting, upgrading pedestrian crossings, building bridges or tunnels or installing traffic signals in junctions. The second category, i.e. the vehicle-related safety measures, includes measures like seat-belt reminder, improved design of car front to protect pedestrians, or the Advanced Driver-Assistance Systems (ADAS), among others. Thirdly, the enforcement-related measures are measures like speed enforcement, speed cameras, drink-drive enforcement etc. Finally, the road-user related measures are the accompanied driving, or elderly driver retraining measures.

2.2. Road Safety Strategic Planning: The "Vision Zero" Ambition

One of the most important milestones in the field of road safety is when the concept of Vision Zero was first introduced in 1994 in Sweden, and has been later adopted in 1997 by the Swedish parliament (Kristianssen, Andersson, Belin, & Nilsen, 2018). The ultimate target of this vision was to have no deaths or serious injuries on the Sweden's roads (Kristianssen et al., 2018). It is an ambition based on the ethical belief that no loss of human life in the roads is acceptable and that everyone has the right to moving safely within their communities (Vision Zero Network, n.d.). Moreover, it underlines the fact that since road users are humans and thus make mistakes it is important to shift from the individual responsibility to the share of responsibilities with system designers and policymakers to ensure the existence of safe systems for people to travel around (Vision Zero Network, n.d.).

This approach is known as the “Safe System” approach and immediately after the introduction of Vision Zero, has started to gain in popularity, since it has been proven highly successful. Even from the first years it managed to cut the traffic deaths of Swedish roads in half even though the number of trips was increasing (Vision Zero Network, n.d.). This led to the “Safe System” approach getting into the attention both of the EU and of other countries outside Europe, like the USA, Australia and New Zealand, among others.

In 2010 the European Commission made a first step towards a common ambition of having zero road fatalities in the European roads, by creating a common framework of actions to be taken by the European Union and its Member States. More specifically, in its Communication COM/2010/0389, the European Union presented the strategic target of the “Policy Orientations on Road Safety 2011-2020”, which was to reduce road fatalities by 50% between 2010 and 2020, by focusing on seven areas of intervention, i.e. education and training of drivers, enforcement of traffic rules, safer road infrastructure, safer vehicles, modern technologies, injuries and emergency response, and vulnerable road users (European Commission, 2010).

Moreover, another important milestone for improving road safety in the European Union is the endorsement of the “Valletta Declaration” by the European Commission. On the 29th of March 2017 the transport ministers of all EU Member States were gathered in Valletta, Latvia to commit into further improving road safety in EU roads. Based on the encouraging results of the “Policy Orientations on Road Safety 2011-2020” until that point, the ministers committed to continue supporting the necessary measures to achieve its objective to half the road fatalities by 2020. Another target that was set by the transport ministers was to also reduce the serious injuries in the EU roads by 2030 compared to 2020. Finally, the Member States were requested by the Commission to prepare a new road safety policy framework for the next decade of 2021-2030, based on those targets.

A few months after the “Valletta Declaration” the European Commission presented in May 2017 the “Europe on the Move” package, putting forward a new approach and setting the long-term target of having zero road fatalities by 2050 (European Commission, 2017). This means that the ultimate goal of the European Union is to achieve the “Vision Zero” ambition by 2050. Moreover, along with the long-term target of having zero fatalities by 2050 a medium-term Strategic Action Plan has been presented which included the intermediate goals of halving the fatalities by 2020 and the serious injuries by 2030, in accordance to the goals that were embraced in the “Valetta Declaration”.

Finally, in 2019 the European Commission in order to successfully translate the aforementioned targets and the medium-term strategic plan into actions published the “EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero"”. In this document it is clearly stated that the “Vision Zero” mindset needs to become more extensively engaged to policymaking but also in the society itself, and also that the “Safe System” approach needs to be implemented at a European level (European Commission, 2019).

2.3. Road Safety in the Netherlands: The “Sustainable Safety” Vision

As has been previously mentioned in the *Introduction*, a similar vision to “Vision Zero” and the “Safe System Approach” have been already introduced in the Netherlands during the 1990s, many years before the presentation of “Europe on the Move” package and the “EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero"” document by the European Commission, and it is being followed ever since. In 2018, SWOV has already published the third version of the “Sustainable Safety” vision for the Netherlands. In short, “Sustainable Safety” is the Dutch Road Safety Policy Framework for the period 2018-2030 and is based on the principles of the “Safe System Approach”. The main aim of this framework is preventing crashes from occurring as much as possible, and if not possible then prevent the severe injuries and fatalities from happening (SWOV, 2018).

When the program was first introduced in 1990s it consisted of two phases. The first phase, called “Start-up Program”, included 24 safety measures and actions that were implemented between 1998 and 2002. The second phase has not been implemented due to the decentralization of policymaking in the Netherlands. However, the idea behind “Sustainable Safety” had still being followed in road safety policymaking and the design of road safety policy measures (Weijermars & Wegman, 2011) until 2018 and the publication of the third version of “Sustainable Safety”.

The most important actor in the Netherlands, which is responsible for the successful implementation of road safety policies, and to ensure that the idea of “Sustainable Safety” is followed by them, is the Ministry of Infrastructure and the Environment. In order to achieve this goal, the Ministry is in close cooperation with many other actors, one of them being SWOV, which has been mentioned above. It cooperates with all the provinces, urban regions, water boards and municipalities in order to increase safety in the road under their jurisdiction (European Commission, 2015b). Moreover, there are other actors that cooperate with the Ministry and take part in the road safety policymaking. Some of the most important of those actors are the (Government of the Netherlands, n.d.):

- Safe Traffic Netherlands (VVN) is responsible for the road safety of neighbourhoods and streets and generally for problems like speeding, driving under the influence of alcohol, and road aggression.
- Regional Road Safety Body (ROV) provides information and education on road safety and also has an advisory role in the design and layout of infrastructure. Every province of the Netherlands has its own ROV.

- The National Traffic Prosecution Team (LPTV) and the Police are responsible for the road traffic rules, and rule violation related matters, like fines or prosecutions to the court.
- Team Alert is a road safety organization run by young people and aims on encouraging the responsible behaviour of young road users.

Table 1 below provides a more extensive list of all the actors that are related to road safety policymaking in the Netherlands, by the policymaking area they are mostly active.

Table 1 – Relevant actors per road safety policymaking area in the Netherlands (European Commission, 2015b)

Policymaking area	**Responsible actors**
Formulation of national Road Safety strategy / Setting targets / Development of the Road Safety programme	Ministry of Infrastructure and the Environment Provinces, urban regions, water boards and municipalities Safe Traffic Netherlands (Veilig Verkeer Nederland - VVN) Institute for Road Safety Research (SWOV)
Monitoring of the Road Safety development in the country	Ministry of Infrastructure and the Environment Provinces, urban regions, water boards and municipalities
Improvements in road infrastructure	Ministry of Infrastructure and the Environment Rijkswaterstaat Institute for Road Safety Research (SWOV)
Vehicle improvement	Ministry of Infrastructure and Environment
Improvement in road user education	Ministry of Infrastructure and the Environment Regional Road Safety Body (Regionaal Orgaan Verkeersveiligheid - ROV)
Publicity campaigns	Ministry of Infrastructure and Environment Team Alert
Enforcement of road traffic laws	Ministry of Security and Justice National Traffic Prosecution Team - Police
Other relevant actors	Council for the Environment and Infrastructure; General Dutch Association for the Elderly (ANBO); De Coninck Traffic Management; Innovative Partners; IPO; Ministries (Interior, Justice, WWI); Sustainable Mobility Platform; Police Academy; Rabobank Netherlands; STIVA (Foundation for responsible use of alcohol); SkVV (Collaborating Metropolitan Regions Traffic and Transport); Foundation for Educational Support Midden-Brabant; TU Delft; VIA Traffic Advice; Volvo Netherlands; NGOs; Consultancies

2.4. Moral Dilemmas in Road Safety

As can be observed from *Section 2.2*, the most common way to measure the effectiveness of road safety policy measures or set targets in Road Safety Strategic Plans is the reduction in the number of fatalities and serious injuries. However, using only the aggregate total of the road fatalities and serious injuries can be sometimes misleading and might not always lead to the most suitable road safety measure option. For example, in the Netherlands the aggregate accident data from SWOV (see Figure 2) show that the total number of fatalities has been rapidly decreasing over the last years, while the total number of severe road injuries has been increasing.

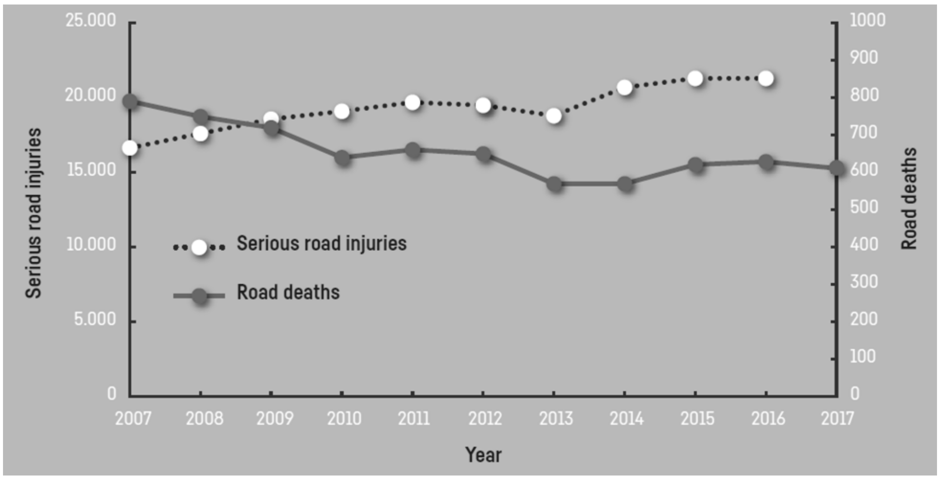


Figure 2 – Total number of road fatalities and severe injuries, the Netherlands 2007-2017 (SWOV, 2018)

However, by taking a more detailed look on the accident data per road user type in the Netherlands, it is clear that this reduction in fatalities has been applied mainly on the motorized traffic, and not to every group of users in an equal manner. The following figure (Figure 3) presents the number of road fatalities and the number of severe injuries per road user type in the Netherlands for the period 1996 to 2011 and 2010 respectively. In those figures the phenomenon described above regarding different types of road users is obvious. Except for car users, the numbers for all the other categories are either more or less stable, or even increased (severe injuries for bike users). According to the Dutch Ministry of Infrastructure and the Environment this phenomenon is more obvious on the most vulnerable or high-risk road user groups, such as cyclists, elderly people and novice drivers (Ministry of Infrastructure and the Environment, 2012).

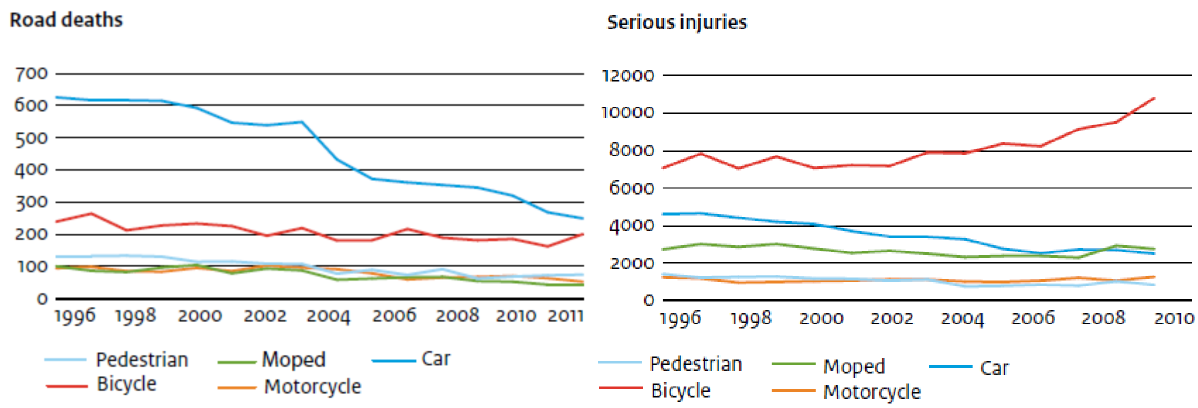


Figure 3 – Road fatalities and severe injuries per road user type, the Netherlands 1996-2011 (Ministry of Infrastructure and the Environment, 2012)

By observing the aforementioned accident data for different categories of road users it can be easily concluded that there are differences in the risks that every group is exposed to. As mentioned above, the vulnerable users constitute on average 50% of all road traffic casualties. This also applies in the Netherlands, where in 2018 the fatalities of vulnerable users (i.e. disabled, pedestrians, cyclists and motorcyclists) consisted the 61% of the total number (SWOV, 2019), as can be seen in Figure 4 below. Vulnerable road users constitute the majority of road fatalities in the less economically developed countries too (van Wee et al., 2013). Generally, low-income groups in every country and region are exposed to a greater risk mainly because they cannot afford to drive a car, thus they have to either use public transport, walk, bike or use a motorized two-wheeler (Fahlquist, 2009). Finally, children, young adults and the elderly are also exposed to greater risks, especially if they are pedestrians or cyclists (Fahlquist, 2009).

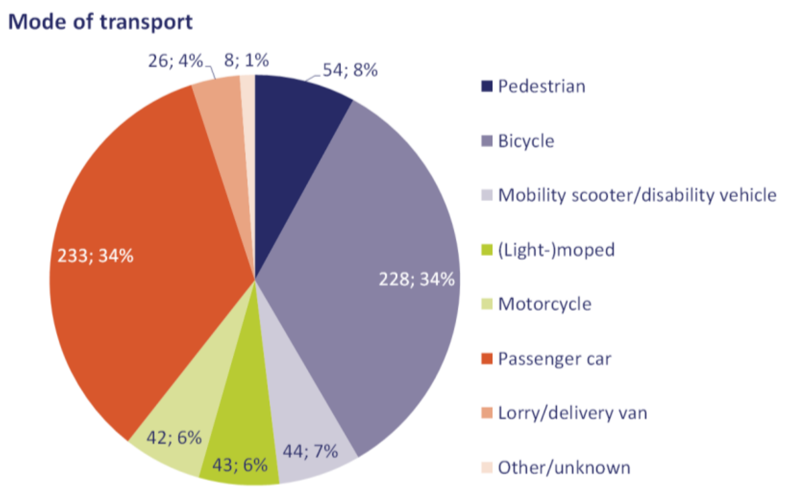


Figure 4 – Road fatalities by mode of transport, Netherlands 2018 (SWOV, 2019)

From these differences in risk exposure between different groups of users it is clear that policymakers are often confronted with the moral question on how to treat those groups to make the road safety policies more fair. Fahlquist (2009) mentions some of the moral questions that arise in road safety policymaking. There is, for example, the argument that since the vulnerable road users are exposed to higher risks, maybe they should be the main focus on road safety policies. There is also the question if more resources should be spent on vulnerable users, and especially child pedestrians, even if it is not the most cost-efficient option. Moreover, for some groups of vulnerable road users, like the motorcyclists, there is the moral dilemma if they should be treated equally with the rest of the vulnerable users, because even though they have higher risk to be killed than a car user, it is their choice to expose themselves in such a risk.

Thus, it is understood that there is a moral difference between, for example, child pedestrians and risk-prone adult motorcyclists or elderly car users. Johansson-Stenman and Martinsson (2008) did a research on the ethical preferences of people regarding the value of life of different categories of road users. The main conclusions of this research were that there is a decreasing value of life with higher age, and that pedestrian lives are evaluated higher than those of car drivers of the same age group. This can be seen in Table 2 below, where Johansson-Stenman and Martinsson (2008) calculated the Social Marginal Rate of Substitution (SMRS) for each category of road user, by having a 70-year-old driver as a case. In this case the SMRS expresses the number of 70-year-old car drivers that are equivalent to saving an individual from each of the other categories. For example, people find it equal to save approximately five 70-year-old car drivers as saving one 10-year-old pedestrian.

Table 2 – Social Marginal Rate of Substitution (SMRS) for different categories of road users (Johansson-Stenman & Martinsson, 2008)

Category of road users	**SMRS**
10-year-old pedestrian	4.646
30-year-old pedestrian	3.030
30-year-old driver	2.489
50-year-old pedestrian	2.394
50-year-old driver	2.159
70-year-old pedestrian	1.428
70-year-old driver (base case)	1

Moreover, a different perspective of this issue arises since by looking at accident data in the Netherlands it is easy to observe that most fatal or serious injury related crashes involve young or elderly car drivers (see Figure 5). This fact can logically lead to the dilemma whether it is fair to increase the legal age of driving from 18 to 20 and also introduce a maximum age limit, thus limiting the freedom of those groups to drive. Such a measure, even though it might have important road safety effects for all road users, it is also expected to reduce the mobility and accessibility of those two age groups.

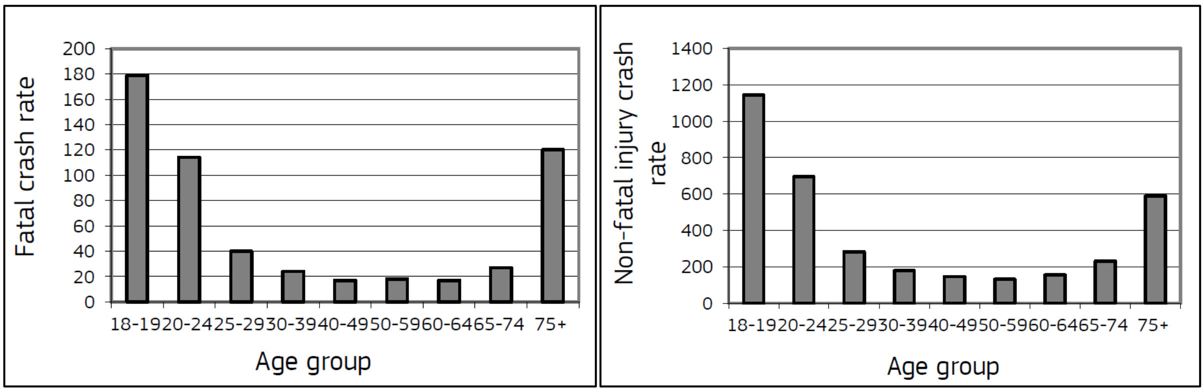


Figure 5 – Number of drivers involved in a fatal and serious injury road crash per billion km travelled by age group, the Netherlands 2005-2009 (European Commission, 2015a)

However, this issue is not only observable in the Netherlands, but rather a worldwide phenomenon. By looking, for example, at the accident data of Australia and the USA (Figure 6 and Figure 7), it is clear that there is a similarity in those graphs with the ones from the Netherlands. The question that arises in those cases is how and to what extend is it fair to trade the road safety benefits of the one side with the reduction in mobility of the other side.

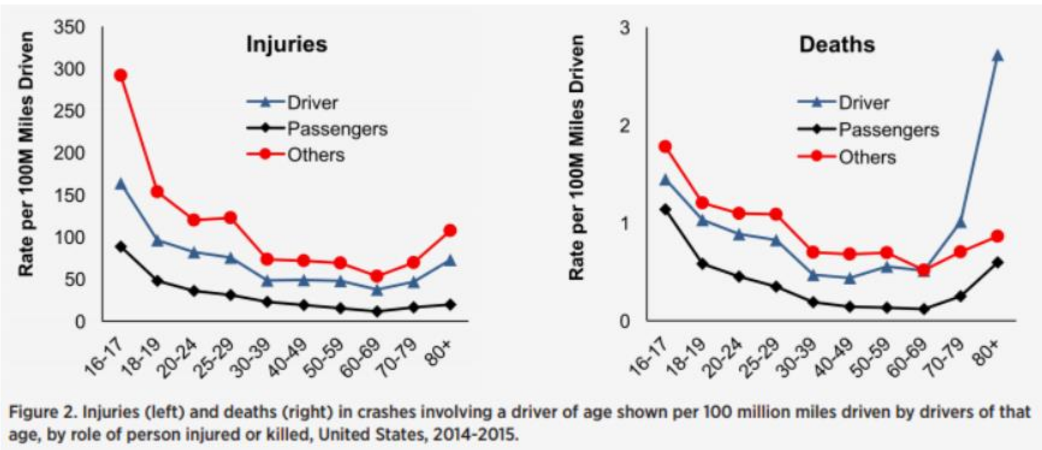


Figure 6 – Number of drivers involved in a serious injury or fatal crash per 100 million miles by age group, USA 2014-2015 (Tefft, 2017)

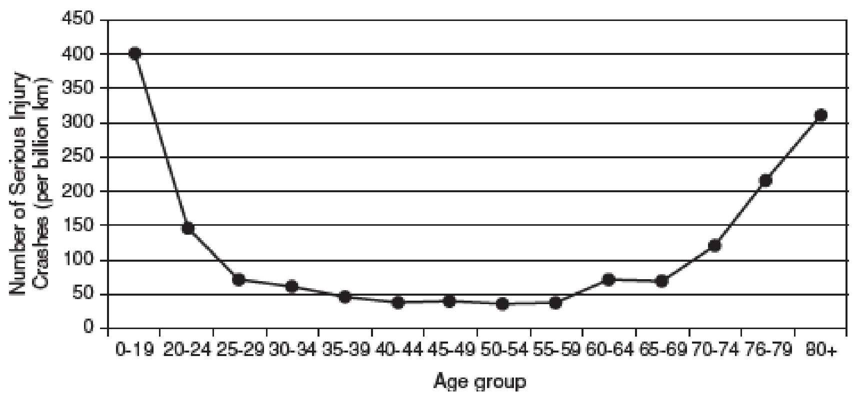


Figure 7 – Number of drivers involved in a serious injury crash per billion km by age group, Australia 1996 (Langford & Oxley, 2014)

Finally, another ethical question related to the distribution of road safety policy effects is who "pays" for the road safety measures and who "receives" the road safety benefits (Elvik, 2009). One example of such a road safety policy is the mandatory retrofit of Advanced Driver-Assistance Systems (ADAS) in the existing vehicle fleet. These ADAS are a wide range of systems that automate, adapt and enhance the vehicle systems to prevent collisions and to improve the comfort of the driving task (Pieters, 2019). In this specific case of the retrofit of ADAS, such as the Advanced Emergency Braking for pedestrians and cyclists, the car users/owners will be the ones who will have to invest in installing those systems in their cars, but the vulnerable road users are the ones who will gain most of the road safety benefits. Thus, the question arises whether it is fair that they pay for the road safety measures, so that other users receive the road safety benefits.

To conclude, it is clear that the field of road safety is full of moral dilemmas, and policymakers are coming across them every time. There is thus the importance to examine people's preferences on those fairness considerations in order to be able to adequately include them in the decision-making process, especially if one of the objectives of policymakers is to design more fair road safety policies for all road users. However, as will be discussed in the next section, the current appraisal methods that are used to assist in the decision-making process have been often criticized due to certain limitations, such as that they mainly focus on the efficiency of a policy. But, as Elvik (2009) argues, "*striving for equity requires to depart from efficiency*".

2.5. Criticism on Current Practices

One of the most widely used appraisal tools, which is also mandatory in many European countries in order to evaluate transport projects is the Cost-Benefit Analysis (CBA) (Bristow & Nellthorp, 2000; van Wee, Hagenzieker, & Wijnen, 2014). The CBA is also used to set priorities for non-infrastructure transport projects, such as road safety policies (Elvik, 2001).

However, in general CBA as a tool focuses mainly on the economic efficiency of a transport project or policy, which is the net contribution of it to the national income, rather than on equity issues related to the project or policy (Martens, 2011).

Moreover, according to Mouter (2017), several Dutch politicians argue that CBA can be misleading in several cases, since despite providing with the possibility to include social impacts, it does not provide any information about their distribution across population groups or different regions. Another disadvantage of the CBA is that it only evaluates the changes resulting from a policy and not the absolute values after implementing it. If someone is interested in the absolute values of an indicator (such as number fatalities) for different groups of people after implementing a policy, then CBA is not an appropriate assessment tool. Furthermore, CBA has the disadvantage that in order to include an effect in the appraisal, it first needs to be expressed into monetary terms (van Wee, 2012).

As regards, road safety policies, as it was mentioned before, the most common indicator that is used is the reduction in the number of fatalities and severe injuries. One method that is used to monetize the number of fatalities and severe injuries is the Willingness-to-Pay (WTP). The WTP expresses the maximum amount of money a person is willing to pay for a marginal reduction in the number of fatalities or severe injuries (Fahlquist, 2009). However, from the perspective of fairness there is a main drawback when it comes to using that method. In general, the WTP of low-income groups is lower than that of the high-income groups (van Wee, 2012). As a result, higher income groups contribute more in the evaluation of different impacts in CBA, because the comparison is based on the WTP and not in the actual welfare gains or losses of those groups (van Wee, 2012).

Another indicator that is widely used in the evaluation of road safety effects in a CBA is the Value of Statistical Life (VSL) (van Wee, 2011). This indicator is based on the WTP method and describes how much people are willing to pay for a reduction in risk. Then a value is given to this risk, which is later multiplied with the traffic volume. This way a price is not given to the actual life of a person, but rather to a “statistical life”. The VSL is used because it reduces the moral objection on pricing human life. However, because this indicator is based on the WTP method, we can easily assume that it has the same disadvantages, such as the difference in the WTP of low- and high-income groups.

A third method that is often used is the Quality Adjusted Life Years (QALY) which expresses a combination of quality and quantity of lost life years (van Wee, 2011). Considering also the quality of life is one of the advantages of this indicator. Another advantage is that it also includes the road traffic injuries, since even though there are not life years lost, the quality of life of a person is reduced. The main contradiction with the WTP method is that QALY assumes a decreasing value of life or risk changes as age increases.

Finally, according to van Wee et al. (2014) even though some effects of road safety policies can be included with the aforementioned methods, there are also costs related to transport safety policies that are often neglected from a CBA. Those costs are related with behavioural aspects, and are called avoidance costs. Avoidance cost describe costs related to people adapting their behaviour due to changes in perceived safety. In that case freedom of movement of some groups of road users may be put in risk.

Freedom of movement is an important element when it comes to ethics and putting it on risk could lead to serious social consequences, such as the social exclusion of individuals or groups of people (van Wee et al., 2014). Social exclusion is a major issue in respect of equity considerations in transport policies. It can be defined as the situation where individuals or population groups are excluded from a certain minimum level of participation in the economic, political and social life of the community, in which they want to participate (Titheridge, Christie, Mackett, Ye, & Hernández, 2014; van Wee et al., 2014).

2.6. Theories of Justice and Fairness in Transport Policies

Before discussing the attempts to include fairness considerations in similar transport research fields in the current appraisal methods, the concept of fairness and also the importance of including it in policies needs to be explained. As mentioned in the *Introduction*, generally, policies are often rejected either during the decision-making process or after implementation, if people find them unfair. Fairness is an important aspect for people, thus if they find it unfair the acceptability of this policy is reduced, and finally the policy is rejected, even if it is cost-efficient. One example, even though it is not directly related to road safety, is the road pricing, which despite being considered an effective measure, it gets rejected because citizens find it an unfair measure (Noordegraaf et al., 2014; van Wee, 2010).

However, one of the main issues when studying fairness issues is that in literature there is no widely acceptable definition of what fairness is. There are, though, a variety of perspectives from which fairness can be examined and also a variety of justice theories that aim to define it. Some of the ethical perspectives from which fairness in road safety can be explored are (Cook & Hegtvedt, 1983; Fahlquist, 2009):

- **Criminalisation**, which is related to the question whether an act should be criminalized and thus if it would be fair to be punished and how.
- **Paternalism**, which is related to the question whether it is fair to limit people's freedom to accept a certain risk and thus limit their individual freedom, by forcing them for example to wear seatbelts, or bike and motorcycle helmets etc., in order to improve others' or even their own safety.
- **Privacy**, which explores the connection between people's right for independence and freedom of movement and their unwillingness to give up some of their privacy rights

by providing their personal data, such to being exposed to surveillance cameras, in order to improve safety.

- **Responsibility**, which is associated with the individual responsibility of people and other actors' responsibility in case of an accident. It is related to the question whether and how this responsibility is distributed and shared in a fair way between different institutions, for example governments and vehicle-producing companies, in order to achieve a safer road traffic environment.
- **Distributional Fairness**, which describes how the effects (benefits, resources, costs etc.) of a policy should be allocated to the recipients (individuals or groups) in a fair manner.
- **Procedural Justice**, which describes the fairness of the mechanisms and procedures involved in the decision making. This type of justice is closely related to the distributional fairness, because the distribution of the effects might be considered fair, but the way that this distribution has occurred might be considered as unfair or biased, resulting in citizens perceiving the policy as less fair.

As mentioned in the *Introduction*, this study is going to focus on exploring the concept of distributional fairness on the topic of road safety policymaking. This means that it will only explore people's preferences regarding the fairness of the distribution of the effects of road safety policies. The other perspectives are beyond the scope of this study. Generally, distributional fairness can vary in three distinctive dimensions (Stanford Encyclopedia of Philosophy, 2017). The first dimension is related to which effects are going to be distributed. This dimension is solely related to the nature of the policy, and in the case of road safety policies those effects could be, for example, the road safety benefits, or the costs to implement a policy.

The second dimension is related to the nature of the recipients, and their categorization criteria. This dimension is closely related to the perspective from which the policy is examined. Depending on the perspective from which distributional fairness of a policy is examined, fairness (or "equity" as it also mentioned often in literature) can be considered in more than one way. Some of the equity types, that can be often found in literature and fairness related studies in the transport field of research, are (Khisty, 2007; Thomopoulos, Grant-Muller, & Tight, 2009):

1) **Horizontal equity**, where fairness in the distribution of the effects (both costs and benefits) of a policy is examined inside categories of comparable individuals, groups or regions, to observe whether the members inside those categories are treated in a fair manner. For example, one way that horizontal equity could be examined is by considering all different types of car users as one group of comparable individuals. Those different types can be, for example, conventional cars, electric cars and diesel cars. To observe whether horizontal equity has been achieved it is important to look if

those different types of car users are treated fairly by a policy, regardless of what has been defined as “fair”.

2) **Vertical equity**, where fairness in the distribution of effects of a policy is examined between groups, depending on how advantaged or disadvantaged they can be considered, regarding the aims and objectives of the considered policy. One example of looking at vertical equity issues of road safety could be to explore how different road user types (pedestrians, cyclists, motorcyclists, public transport users, car users etc.) are treated based on their vulnerability or risk exposure. In that case, the most disadvantaged users can be considered to be pedestrians and cyclists, while car users the most advantaged. Thus, it is important to see whether fairness has been achieved regarding this ranking of the different groups.
3) **Spatial equity**, which refers to the geographical location of individuals, groups, regions that receive the effects of a policy and whether they are distributed in a fair way among these locations.
4) **Social equity** is associated with the distribution of effects of policies, but examined in a personal, economic or social perspective for different categories of individuals, groups and regions. For example, social equity issues can be examined as regards the costs of a policy and how they are distributed to different income or age groups.

The third and final dimension is the basis on which the distribution should be made in order to be defined as fair. Apart from the different equity types that can be used to examine fairness issues, there is also a variety of equity principles and theories of justice in literature that can be used to describe how the distribution should be made in order to achieve fairness. Some of those principles, for example, that have practical applicability in transport project and policy appraisal are (Khisty, 2007; Pereira, Schwanen, & Banister, 2017; Thomopoulos et al., 2009; van Wee & Geurs, 2011):

1) **Equal shares distribution**, meaning that a policy is fair when the effects are distributed equally to everyone.
2) **Utilitarian theory**, that aims in maximizing the net benefits of all people and gives an equal weight to everyone.
3) **Egalitarian theory**, where fairness is achieved when everyone is considered equal. Thus, policies that reduce current inequalities and give bigger benefits to the lower socioeconomic groups are following the egalitarian theory.
4) **Rawls’ theory of justice** or **Rawls’ egalitarianism** argues that a policy should not aim to maximize the total benefits, but only to provide the least advantaged members of society with the greatest benefits. The benefits of the other groups play no role in this theory.
5) **Sufficientarianism**, which states that policies should give priority on groups of people that are below a certain minimum threshold. This theory focuses on the absolute levels

of important indicators before and after implementing the policy and not on the differences in the benefits provided between different groups by the policy.

6) Distribution based on **maximizing** the average net benefits with a **minimum floor benefit** for everyone. In this case fair is when there is an attempt to maximize the benefits with the constraint that specific groups of people receive a certain minimum amount of the benefits.
7) Distribution based on **maximizing** the average net benefits with a **benefit range constraint.** In this case fair is when there is an attempt to maximize the benefits, without allowing differences over a certain amount in the benefits of different groups of people.

To conclude, it is easily understood that to create publicly acceptable policies, fairness issues need to be taken into account. Moreover, the fact that there are many types of equity and ways to define fairness makes it very difficult for an appraisal tool to include all these considerations in an adequate way. In the next section, the attempts of researchers to include equity considerations in the appraisal methods in other transport fields, since there is scarcity in literature regarding road safety policies and equity, will be discussed.

2.7. Attempts to Include Distributional Fairness in Similar Research Fields

In general, transport policies relate to three main topics, which are accessibility, the environment and safety (van Wee et al., 2014). Even though it is important to include fairness in the appraisal process, there is scarcity of literature and studies on the topic of transport safety and distributional fairness. There are, though, some researches that have tried to include fairness considerations in the appraisal of transport projects or policies related to accessibility. In this section, a brief literature review on those studies will be conducted in order to see how they attempted to include fairness considerations in the policymaking process and appraisal and what we can learn for the case of road safety policies.

In literature there are two ways to include fairness considerations in the evaluation process of a policy related to mobility, as will be presented below. In the first method fairness is incorporated in the existing CBA framework, and it consists of the use of distributional weights or equity values. Adler (2016) has identified several researchers that have proposed using the distributional weights and equity values on a CBA, but they have been rarely used in practice (Martens, 2011). According to Martens (2011) the use of distributional weights and equity values can potentially eliminate some equity issues. For example, by using equity values the total benefits of low-income groups would receive a higher weight than those of high-income groups. This way the problem, that was mentioned in *Section 2.4* when converting some effects into monetary terms with the WTP method can be reduced.

However, one important argument against the use of distributive weights and equity values is that they are contradictory to the underlying theory of CBA, which is the utilitarian theory that aims to maximize the sum of the benefits of all people and gives an equal weight to everyone (Pereira et al., 2017). Elvik (2001) argues that if the basic principles of CBA are rejected, then it is not appropriate to apply the technique at all. The main advantage of CBA is its objectiveness towards everyone, which in the case of using weights is reduced. This might explain why the above method hasn't found an extensive practical application.

On the other hand, there is another group of scholars (e.g. Johansson-Stenman, 2000; Martens, 2011; Wortelboer-van Donselaar & Visser, 2012) that suggest conducting a separate impact analysis, as supplementary information to accompany CBA. This analysis needs to be highly associated to the indicators that are closely related to the objectives and effectiveness of the proposed policy, expressed preferably in non-monetary values. However, there is a high level of complexity in conducting an individual equity analysis. The main issue, as mentioned above, is that there is no universally acceptable term or definition to describe equity (Mouter, van Cranenburgh, & van Wee, 2017; van Wee & Geurs, 2011). Moreover, apart from the different equity types there are more difficulties in conducting an individual equity analysis, like the variety of impacts to take into consideration and the ways to measure them (Mouter et al., 2017; van Wee & Geurs, 2011).

2.8. Moral Dilemmas and the Discrete Choice Approach

From the previous section it is obvious that many researchers are trying to find ways to include moral aspects, such as equity, in the evaluation process of transport projects or policies, or even incorporate them in the evaluation tools, such as CBA. Noticing this attempt Chorus (2015) argues that applying the Discrete Choice Approach in the domain of moral choices can offer a more empirically rooted understanding of how individuals make those moral trade-offs, which will be beneficial for those attempts. The Discrete Choice Approach is a widely used technique by economists and as Roemer (1998) argues *"the economist's way of thinking can check the consistency of a philosophical theory or provide a concrete formulation (a model) to make more precise some of its still vague assertions. It can often translate a philosophical view about distributive justice into a concrete social policy"*.

Following the argument of Chorus (2015), Mouter et al. (2017) conducted one of the first empirical studies related to the preferences of citizen's for distributive justice and their willingness to trade effectiveness for spatial equality. Their study included, among others, notions of transport safety as an effect of a transport investment program. In one of the Stated Preference Experiments that were conducted participants were asked to choose between road safety programs that differ in the total reduction in the number of fatalities and their distribution between 2 regions in the Netherlands. Mouter et al. (2017) have explicitly mentioned in their study that they agree with Chorus (2015) on the usefulness of conducting Stated Preference experiments to improve the understanding of moral trade-offs, and they are proposing to extend their study by either including other ethical notions too (rather than spatial equity) or to introduce the consumer context in the experiment.

Finally, the Stated Preference Experiment method has the advantage that people can choose over hypothetical scenarios that do not exist yet (van Wee, 2011). This is convenient since fairness is an unobservable characteristic and for that reason it is omitted from the evaluation of road safety policies. Moreover, following this approach can help to avoid one of the main disadvantages of doing an analysis based on accident data or statistics related to road safety policies, which is the scarcity or the reliability of the data. According to Derriks and Mak (2007, as cited in van Wee et al., 2013) crashes that include motorized vehicles are better registered than crashes with non-motorized transport, such as pedestrians and cyclists. This can reduce the validity of the analysis, especially in the Netherlands, with the extensive bike use.

2.9. Contribution of this Study

As mentioned in the *Introduction* this study aims to explore the preferences of citizens regarding fairness issues related to the distribution of the effects of road safety policies, in order to provide with policy recommendations that will result in promoting more fair and acceptable road safety policies. From this literature overview two major motives have been found in order to focus on the topic of distributional fairness in the field of road safety. First of all, people consider fairness as an important aspect of policies and can be a show-stopper for their implementation. Furthermore, despite the huge ethical dilemmas, mentioned in *Section 2.3*, that road safety policies contain, there is little understanding on how people perceive those moral trade-offs.

This study's scientific contribution is to gain knowledge on people's preferences for distributional fairness regarding the effects of road safety policies, by applying the Discrete Choice Approach. Firstly, it will be one of the first studies, to my knowledge, that will attempt to get a better understanding on how people perceive fairness of the distribution of effects of road safety policies and on which are the factors that influences this perception of fairness. Moreover, this study will attempt to explore what is the influence of this perceived fairness, compared to other aspects, on people's preferences over different road safety policy options. This way it is possible to observe the willingness of people to pay for distributional fairness in road safety, or their willingness to exchange any of the aspects of a road safety policy for an improvement in the level of distributional fairness.

3. Methodological Approach

In this chapter the research methods for each of the methodological steps that will be followed are going to be discussed. First, the primary data collection methods that consist the preliminary research, i.e. Focus Group Approach and the individual exploratory research interviews, are presented in *Section 3.1*. Then, the main experimental method, which is the Stated Preference experiment, is discussed in more detail, in *Section 3.2*. Finally, *Section 3.3* presents the methods that will be followed in order to analyse the data that have been gathered with the Stated Preference experiment of this study.

3.1. Primary Data Collection Methods

As has been previously mentioned, before conducting the main experiment it is important to conduct a preliminary research. The aim of this research is to obtain all the necessary primary data in order to prepare the main experimental method, which is the Stated Preference experiment. The main experimental method will be described in more detail in the next section (see *Section 3.4*). This preliminary method consists of two parts. The first part consists of a focus group discussion, while the second of a number of individual exploratory research interviews.

A focus group discussion is a qualitative research technique from the category of group interviews. The main characteristic that distinguish it from other interview techniques is that it uses the interaction between the participants during a discussion focused on a particular topic of interest, in order to gather (primary) research data. This means that it is a form of a less structure interview that aims to engage the participants into a conversation with each other, rather than having them answer questions asked directly to them. During a focus group discussion, it is not necessary that the participants reach an agreement, but rather exchange information, experiences and their points of view on the topic.

This method is useful in getting primary research data on new and unexplored topics, and also to get a better understanding on the experiences or preferences of citizens. It is preferred when it is important to examine not only what people think, but also the "how" and "why" (Kitzinger, 1995). The aim of conducting this focus group discussion is to promote this interaction between the participants in order to gather more information related to their understanding of distributional fairness in road safety policies and the factor that influence this perception, that would not be possible to gather using only the individual interviews questionnaire. This way it will be ensured that no important attribute is left out from the main experimental design.

Most studies involve just a few groups, and some combine this method with other data collection techniques (Kitzinger, 1995), such as the individual exploratory research interviews mentioned above. A typical focus group interview includes around 6-8 persons and lasts approximately 1 to 2 hours. According to Lederman (as cited in Rabiee, 2005) it is not necessarily important that the focus group participants are a representative sample of the examined population. It is more important that the group is characterized by homogeneity, meaning that they have similar sociodemographic characteristics (e.g. age-range, ethnic, social class background etc.) and are comfortable with each other in order to engage into a conversation (Rabiee, 2005). Considering the above, in this specific study only one focus group has been conducted, between students of the Delft University of Technology, since this method will be combined with the results of the individual research interviews.

On the other hand, the individual exploratory research interviews have been conducted among the general public, but preferably with non-student or academic people of a different age group than the people who will participate in the focus group session. The reason that this method has been chosen is that it would be difficult and time consuming, if not impossible in the time span of this study, to organize another focus group with more groups of people. The format of the questionnaire of those individual interviews will follow the one of the focus group session. This means that this questionnaire will be in the form of a semi-structured questionnaire too, where the participants will be asked to substantiate their answer or give examples, in order to gain more concrete information and identify the important factors that play a role in considering a road safety policy.

To conclude, both the information of the focus group discussion and the individual exploratory research interviews will be used in order to see if there is a way to connect people's preference for fairness with the existing equity theories that can be found in the literature (see *Section 2.6*). Moreover, they will be used in order to identify the most important attributes to be included in the main experimental method, which is the Stated Preference experiment, and will be discussed next. This means that by conducting the preliminary experiments, the first sub-question (SQ 1) together with half of the second sub-question (SQ 2a) that have been formulated in the *Introduction* will have been answered.

3.2. Main Experimental Method

After gathering all the necessary information from the preliminary research, the main experimental method, i.e. the Stated Preference experiment, follows. As mentioned in the *Introduction* this research needs to fill two specific knowledge gaps to achieve the research aim. Firstly, it is necessary to identify the important aspects that affect people's perception of distributional fairness regarding the effects of road safety policies and then measure this perception, and secondly to observe how people trade this perceived distributional fairness against other aspects of the policy (like effectiveness or cost), and to what extent they are willing to do so.

Answering those two questions in one Stated Preference experiment will probably involve a large number of attributes, which will result in the problem of information overload and respondent fatigue, and consequently reduce the validity of the experiment. In the transport related literature this risk is often alleviated by following a combined Hierarchical Information Integration (HII) and integrated choice experiment methodology (Molin & Timmermans, 2009). This methodology is an adaptation of the conventional Hierarchical Information Integration, which splits the large number of potential influential attributes into smaller subsets. Those subsets consist distinct sub-experiments where respondents receive less information when asked to make a choice, thus making the whole experiment less demanding (Molin & Timmermans, 2009).

This means that for this study, since there are two distinct tasks to be done, the construction of two distinct Stated Preference Experiments is required, similarly to Molin, Blangé, Cats and Chorus (2017) who followed a HII and integrated choice experiment combination methodology in the field of air travel safety. These two Stated Preference experiments will be linked together by the perception of fairness, as can be seen in Figure 8, which shows a graphical representation of the proposed methodology. The first experiment is related to the citizen's perception of fairness of road safety policies and how the attributes that influence it contribute to this perception, while the second one is related with the importance of this perceived fairness in the preference of citizens over specific road safety policy alternatives.

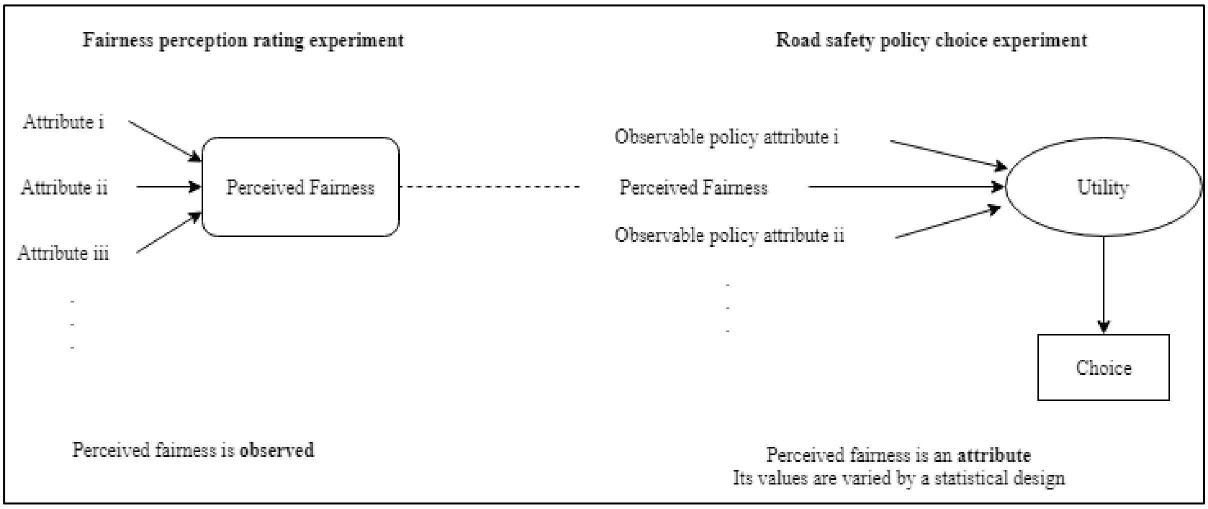


Figure 8 – Graphical representation of the simultaneous Stated Preference experiments (adapted from Molin et al. (2017))

In the first experiment, respondents will be asked to evaluate different road safety policy options. To evaluate those options, they will have to score them on a rating scale based on how fair they think they are in their opinion. Those road safety policy options will be described in terms of attributes that are influential on people's perception of fairness, based on the preliminary experiments. From this experiment the extent to which each attribute determines the perception of fairness of people will be estimated. The advantage of this first experiment is that it resolves the difficulty of defining and measuring fairness, in order to include it consequently into the second Stated Preference experiment.

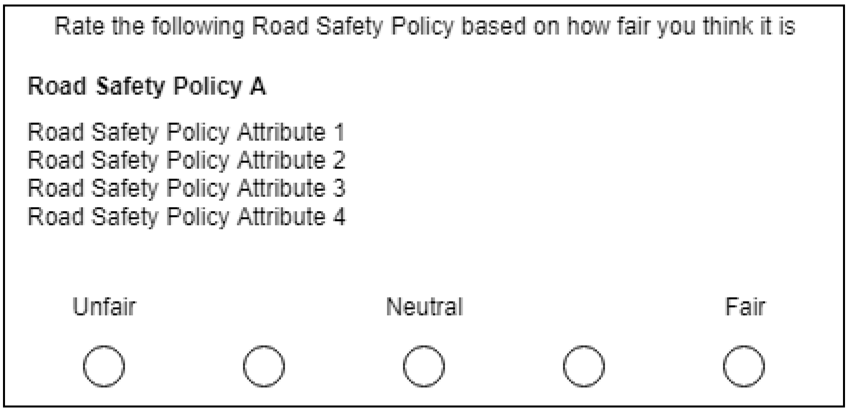


Figure 9 – Rating experiment conceptual example

In the second Stated Preference experiment, the perception of fairness will be included as an attribute of the experiment, together with other observable policy attributes that are considered important when deciding over different road safety policies. Those observable policy attributes (e.g. cost, reduction in fatalities etc.) will be also obtained from the preliminary experiments and from the relevant literature. The values of perceived fairness in this experiment will be determined by a statistical design. Respondents will be asked to choose over several hypothetical road safety policy options that include fairness implications, as shown in Figure 10 below.

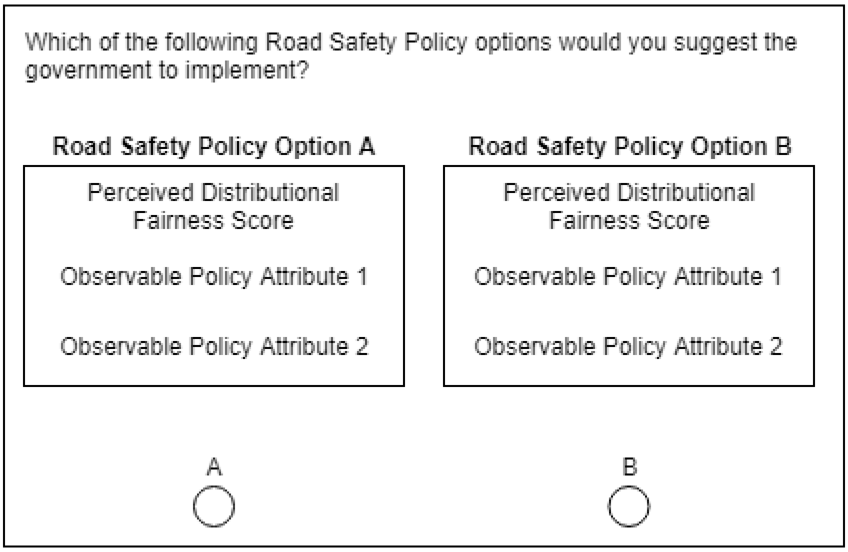


Figure 10 – Choice experiment conceptual example

From the choices of the respondents in both Stated Preference experiments it is possible to estimate to what extend the factors that have been identified influence their perception of fairness and also to estimate how this perceived fairness is traded-off against the other aspects of road safety policies, such as their effectiveness and cost. From the Stated Preference experiment SQ 2b and SQ 3 will have been answered.

Finally, during the experiment several personal characteristics of the respondents are going to be measured. The reason for that is firstly, to see if a representative sample have been ensured, containing participants from all sociodemographic groups, if possible, and also to test whether some of those characteristics affect their preferences over road safety policies. This way it is possible to explore to what extent the estimated parameters of both models differ between the different categories of the background variables, and thus include in the model the interactions of the background variables and attributes which are statistically significant. The interaction that will be tested are going to be presented more analytically in the *Data Analysis* chapter.

3.3. Data Analysis Methods

The next step after conducting the two aforementioned Stated Preference experiments is to conduct the analysis of the gathered data. This section describes briefly the two methods that will be used in this study. As it is can be clearly seen, each of the experiments has different characteristics, thus requires a different data analysis method. For the rating experiment a Linear Regression analysis has been chosen to be performed, as will be described in more detail in *Section 3.4.1*, while for the choice experiment, the main experimental method is going to be used (See *Section 3.4.2*). More details on the technical characteristics of both data analysis methods are going to be discussed during the *Data Analysis* chapter.

3.3.1. Perceived Distributional Fairness Data Analysis Method

The first experiment, i.e. the rating experiment, consists of observations where the dependent variable fits into a scale. Such data can be analysed either with a Linear Regression model or an Ordinal Logistic Regression model. Either method has different characteristics and assumptions regarding the data, thus the one that will be selected to be used will be the one that fits best the aforementioned methodology based on their advantages and disadvantages.

One of the major advantages of Linear Regression is its simplicity due to the linear relationship between the different levels of fairness, which means that the intervals between those levels are assumed to be equal. However, one of its disadvantages is that it is not confined between the margins that are described by the levels of fairness. This means that the expression could potentially take values outside of the scale's range of values.

On the other hand, the Ordinal Logistic Regression has the advantage to take values only inside the predefined range of fairness levels. However, in the ordinal logistic regression, it is assumed that the relationship between the levels is not linear and that the intervals are not equal. Even though this characteristic fits better in this case, it requires to include all the levels of fairness in the second experiment in order to connect the two experiments, since the lack of linearity does not give the possibility to perform interpolation. Consequently, this requires a larger number of profiles to ensure orthogonality (for the usefulness of orthogonality see *Section 5.2*) since the perceived distributional fairness attribute will have 5 attribute levels.

Based on the aforementioned reasons, for this study the Linear Regression has been considered more suitable. The main reason was the assumption that the intervals are equal between the different levels of fairness, which allows an interpolation to be performed. Therefore, the necessary profiles of the choices that a respondent will have to perform will be less, ensuring that they will not quit the experiment due to fatigue. As mentioned above, the Linear Regression assumes a linear relationship between the dependent variable, which in this case is the Perceived Distributional Fairness, and the independent variables, which are the attributes of the experiment. This relationship can be expressed with the following formula:

$$Yi = c + \sum (\beta i * Xi)$$

Where Y_i is the dependent variable (Perceived Distributional Fairness), c is a regression constant, and β_i is the parameter for each dependent variable X_i.

3.3.2. Road Safety Policy Choice Data Analysis Method

As regards the choice experiment for the preference over different road safety policy alternatives, the main method of this study, namely the Discrete Choice Approach, is going to be followed. In this study the Random Utility Maximization (RUM) theory firstly introduced by McFadden (1973) will be applied. This theory assumes that people choose the alternative of a specific choice set that give them the highest utility. The utility of each alternative is influenced by several factors that consist the attributes of the choice experiment and can be described by the following expression.

$$U_i = V_i + \varepsilon_i = \sum_m \beta_m x_{im} + \varepsilon_i$$

Where U_i is the total utility of alternative i, V_i is the systematic utility, ε_i is the random utility, x_{im} is the value of attribute m of alternative i, and β_m is the importance of attribute m to the systematic utility.

The random utility is related to aspects that influence the total utility but cannot be observed or have been left out of the Stated Choice experiment, and also random errors, inconsistencies in choices, and interactions between the different influential factors that have not been taken into account. The only part of the utility that can be observed is the systematic utility. However, by knowing the systematic utility only the probability of choosing an alternative can be calculated. The probability of choosing an option can be calculated using the following formula.

$$P_i = \frac{e^{(Vi)}}{\sum e^{(Vj)}}$$

Where i is the alternative whose probability (P) is calculated, and j are all the alternatives of the choice set (including alternative i).

Based on the RUM theory two models will be initially estimated, one simple Multinomial Logistic Regression (MNL) model and a panel effect Mixed Logit (ML) model. After that the one that fits better will be further analysed in order to add the interaction effects of perceived distributional fairness with the other attributes of the choice experiment. Those models are going to be used in order to estimate the importance of each attribute to the choice of people regarding different road safety policy alternatives. The interaction effects of perceived distributional fairness with the other attributes will show how an increase in the level of distributional fairness perception can influence the importance of the other attributes. In other words, by including the interaction effects it is possible to observe whether a reduction in distributional fairness can be compensated with an increase of the benefits, or a reduction of the costs of a road safety policy, and also up to what extent does this compensation differ for the different levels of distributional fairness perception.

4. Preliminary Research

In this chapter the preliminary research, that has been mentioned in *Section 3.2*, and is necessary to gather the primary data to design the Stated Preference experiment is discussed in more detail. Firstly, the process of conducting the Focus Group Discussion is presented in *Section 4.1*. This includes the preparation, execution, analysis and the findings of the session. Then the individual exploratory research interviews (*Section 4.2*) are presented in the same way, and finally the summed conclusions of both methods (*Section 4.3*) that will be used to design the Stated Preference experiment.

4.1. Focus Group Discussion

The Focus Group is a primary data collection technique, suitable when someone is interested in the “how” and the “why”, rather than the “what”. The data is obtained from the interaction among the participants, thus open-ended questions are more preferred over “yes or no” questions, in order to trigger a conversation between the participants. The proposed number of questions is between 5 to 7 and the most common format regarding the session is as follows (Krueger, 2002).

- Introductory question
- Transition question
- Key questions
- Ending question

The first version of the Focus Group questions has been formulated based on this format. Those questions were later tested in a pilot Focus Group in order to design the final version of questions that will be used in the actual Focus Group session. As mentioned in *Section 3.2*, the aim of this focus group discussion is to get a better understanding of how people perceive fairness and to identify the important factors that play a role in considering a road safety policy as fair. This information will help to select the attributes and the attribute levels of the Stated Preference experiment. Keeping the above in mind, the Focus Group questions have been constructed, as presented in the following section.

4.1.1. Preparation of Discussion Questions

In the first version of questions for the Focus Group session of this study, the introductory question has been selected to be a general question about the importance of road safety. The aim of this question is just to introduce the participants to the topic, to make them feel more comfortable and to engage them into a conversation with each other.

Then two transition questions are introduced. The aim of the transition questions is to gather general information about the opinions of participants on the discussion's topic. The first question is about how they perceive fairness of road safety, while the second one is related to their opinion about the importance of fairness of road safety policies in the decision-making process. Another aim of the transition questions is to prepare the participants for the more detailed questions that will follow, which are called key questions.

For the pilot version of the focus group discussion, two key questions have been designed as topics of discussion. For the first key question, a famous technique that is widely used in focus group has been selected, which is the role playing. In this part of the session the participants are asked to imagine that they have a minute to talk to Minister of Infrastructure and Water Management on the topic of fairness of road safety policies. Based on that, they are asked to mention the 2 or 3 most important suggestions that they would make in order to ensure designing and choosing a more fair road safety policy.

The second key question of the focus group, which is also the last question, demands that the participants rate seven statements that have been formulated based on the moral dilemmas that have been mentioned in *Section 2.3*. In short, the statements of the rating task are related with the following perspectives:

- Whether fairness should be included in the decision-making process, or only effectiveness
- Risk exposure of road users
- Risk-prone road users vs risk-exposed road users
- Who pays for the benefits and who receives them
- Income group of road users
- Spatial equity
- Age group of road users

The reason for having this question as the last one, is to avoid mentioning any examples that will bias the opinion of the participants for the rest of the session. The rating would be based on the level of their agreement with specific statements on the aforementioned perspectives. However, the goal of this task is not to observe who agrees and who disagrees with those statements, but rather how they think regarding those dilemmas and how they substantiate their answers.

Finally, a concluding question follows, where participants are asked to state the most important thing that was mentioned during the discussion, either by them or by someone else. Then the moderator of the session (who in this case is the author of this study) makes a summary of the discussion, before ending the session, to ensure that there is no important statements or information missing.

4.1.2. Pilot Focus Group Session and Adjustments

Before conducting the actual Focus Group session, a pilot session has been held on May 17th with the participation of three students of the Delft University of Technology. The aim of this pilot session was to observe whether the questions are clear to the participants, and the expected time per question is sufficient in order to engage them into a fruitful conversation that will make it possible to draw several safe conclusions about the way they perceive fairness of road safety policies and the factors that influence it.

Based on this pilot session, several adjustments took place on the questions that have been used in the actual focus group session. The first change is related with the introductory question, where participants were asked to discuss on the importance of road safety in general. Even though the aim of this question was just to make them feel more comfortable and to engage them into a conversation between one another, it resulted into diverting the focus from the fairness of road safety policies to the importance of road safety in general, occasionally during the discussion. For that reason, this specific question has been chosen to be removed from the actual focus group questions.

Moreover, some detailed adjustments on the formulation of the questions, and more specifically the statements related to the ethical dilemmas from the literature, took place in order to increase their clarity. The final form of the discussion questions of the Focus Group session can be found in *Appendix B*.

4.1.3. Focus Group Session

As mentioned before, homogeneity of the group in a Focus Group discussion is essential, thus participants with similar characteristics are preferred over having a representative sample. The participants should feel comfortable with each other and the interviewer. For that reason, the group of participants that had been selected to participate consisted of students from the Delft University of Technology, similarly to the pilot session. Six students have been recruited to participate in the session that took place on May 24th. The main characteristics of those participants are presented in Table 3.

Table 3 – Characteristics of Focus Group Discussion participants

No.	**Gender**	**Age group**
1	F	18-25
2	M	26-35
3	M	26-35
4	M	26-35
5	F	26-35
6	F	26-35

4.1.4. Data Analysis and Findings

The Focus Group session took approximately 1 hour and 15 minutes and the main findings are presented in this section. A general remark about the discussion is that the participants had often the tendency to drift the conversation more in the effectiveness of the road safety policies or accessibility issues, rather than the fairness of the policy itself. However, in this section only the most important findings that are important for this study and are related to distributional fairness, are going to be presented in more detail.

From the discussion of the first question, the most important finding is that participants in general perceive a fair road safety policy as the one that gives priority to the most vulnerable users. In addition, they mention, for example, that bike users and car users are not equals, so it is not fair to treat them as such, but rather treat them based on their needs. Therefore, they think that different transport modes should be treated differently. This is associated mainly with their vulnerability and their exposure to risk. Two representative examples of what participants stated during the focus group discussion, related to this aspect, are the following.

"But you are not equal with a car when using a bike. When driving a car, you are more safe."

"...different traffic lights for pedestrians and bikes, because they need different time to cross. This is fairness."

Furthermore, during this part of the discussion several examples were given where different users are treated differently from road safety policies, due to their characteristics or based on their needs. Those examples were related to either infrastructure or road safety regulations, as can be seen below. This indicates that maybe different aspects related to fairness would be relevant or important to look at based on the type of the road safety policy that is being examined.

"... there is also separation (of road users). Here (in the Netherlands) you don't drive your bike on the road."

"People on a wheelchair have difficulty to use different features on the road as opposed to a fully able person."

"...age and experience (new and experienced drivers) regarding the regulations..."

During the discussion of the second question several examples have been mentioned that helped identify other aspects related to fairness, like regulations or infrastructure that focuses on increasing speed and accessibility of specific road users, reducing that way the safety of other users, and vice versa. This means that people think that safety of some groups is traded-off, with other aspects like speed, accessibility and mobility of other user groups.

"(fairness) it makes people feel comfortable and safe to use the road more often. Because if people don't feel safe to use the road they stay home. It makes different groups of people to be more comfortable."

"… it doesn't mean that if it is fair it is going to be safe. It is not fair for the car to stop, but he had to stop in order to not kill the pedestrian. Sometimes you have to stop when you drive, which is unfair (more travel time) but it's the safe thing to do."

"- So, if you drive a car and a bike passes not from a crossing, you have to stop every time?

- Yes of course, but this is not fair for the car user. "

Moreover, based on two other statements of the participants it is concluded that several personal characteristics (e.g. preferred mode of transport) possibly affect an individual's perception of fairness and their preferences regarding fairness compared to other aspects.

"Personally, I have felt the unfairness both from the aspect of the pedestrian and the car user."

"… (fairness) it's subjective. For someone it is more important to focus on pedestrians rather than cars. Here I find strange that bikes have right to pedestrians. I would give right to pedestrians."

Furthermore, several interesting statements were made during this part of the discussion. The vulnerability of the different types of road user has been mentioned again, but the way they were formulated helped to link these aspects with several equity types and theories. The statements are the following:

"I think everybody has to have equal rights on the road. If you have a conflict between them then the most vulnerable should have the right to use the infrastructure"

"For me in a pyramid, pedestrians would be on the bottom (most vulnerable) and the higher (less vulnerable) would be the trucks"

Based on these statements and the ones from the first question, we could assume that one way that would be interesting to examine the fairness of road safety policies is the vertical equity on different transport modes, where fairness is achieved based on the egalitarian theory, which states that policies that reduce current inequalities and give bigger benefits to the lower groups are more preferable.

As regards the part of the key questions, some interested findings have been added to the ones mentioned above. From the first key question one main finding is that, again, the trade-off between accessibility or speed of some users with the safety of other users is mentioned, however this time is was based on the spatial characteristics of the policy. Participants think that people might be willing to trade off differently based on the spatial characteristics of the area they live.

"There is also a difference, based on the area of the town you are living. In the outskirt roads are bigger, and some city centers are car free. So, fairness is not a universal thing. It depends where you live."

Another interesting finding from the first key questions is that three out of the six participants have proposed that policymakers should try to include people in the design and policymaking phases. They think that including people, and more specifically all types of road users, in the design and decision-making process will result in more fair road safety policies. This is an aspect related to a different perspective of justice than the distributional justice, which is the procedural justice. However, as mentioned in *Section 2.6* procedural justice is closely related to distributional justice.

During the second key question, i.e. the rating task, of the focus group discussion, there were also several interesting statements made. First of all, participants believe that some characteristics of the people that a road safety policy aims at, should play a role in the decision making. Those characteristics are the age and mode of transport. However, the income group that people belong shouldn't play a role in the distribution of the benefits.

"Fatalities happen due to certain characteristics. So, you should analyze a little bit everything, like age and mode."

"I agree with some of the characteristics. …not with income"

Moreover, for a third time during the discussion, the trade-off between the safety of vulnerable users and speed or accessibility benefits of other users has been mentioned. More specifically, as can be seen below, what was mentioned is that since some transport projects aim to increase the speed and accessibility of cars, by reducing the available space rights and safety rights of vulnerable users, road safety policies should try to focus more on those users. The exact statement, with which everyone agreed, was:

"Roads exist to provide faster transportation for the other modes. By the very existence of the roads they (vulnerable users) are scarifying a measure of their safety and space rights, so they should be compensated with a more safe and fair (policy) design."

Some of the participants made the interesting statement that it is possible to find risk-prone road users in all transport modes. For that reason, it is not fair to consider motorcyclists as a risk-prone user group, but as a part of the vulnerable users.

"… you can find risk-prone (users) in cars too."

"It's an opportunity you are given, to ride a motorbike. Everybody should have the opportunity to choose which mode to take. Because otherwise you make a distinction between transport modes. If I know I am less protected I wouldn't like to use this mode."

"Since they are vulnerable, they should be treated like the rest of them, despite that there might be some that are risk-prone"

Another important finding is that, as regards the dilemma of "who pays" and "who gains the benefits" of a road safety policy, it seems that it could play an important role on whether people think a policy is fair or not. This is a similar finding with the one related with the trade-off of safety of some groups and accessibility or speed of other groups, but it is associated with the monetary aspect of the policy.

"I think it is unfair for the driver to pay… it should be promoted by the government because everybody (both cars and vulnerable users) will benefit."

Not until it was time to discuss it did the participants seem to be interested in how the benefits of the road safety policies are spatially distributed, despite that they have previously mentioned that the focus area of a policy affects how fairness is defined. However, during the discussion it was concluded that spatial equity actually does play a role in their perception of fairness of road safety policies and that policies should try to maintain at least a minimum level of safety for each region or area.

"Different regions have different needs."

"In every region you need to be safe."

Finally, one interesting finding from the participants' discussion on the last question is that a combination of age and mode of transport of those who receive the negative externalities of road safety policies might affect their perception of fairness. Even though the policy measure was the same for both age groups, they had different preferences for old drivers than young drivers. Furthermore, during the focus group session the fairness of implementing a policy (such as the 30km/h speed limit in urban areas) that sacrifices car users' speed (who are all adults) to save child pedestrians has been mentioned as an example on this aspect.

4.2. Individual Exploratory Research Interviews

Since the Focus Group session has been conducted only among students, it seemed preferable to enrich the primary data with information from other groups of people. For that reason, individual interviews have been conducted among individuals that are not currently students and are older than 35 years. The aim of the interviews is the same as in the Focus Group Discussion, which is to get a better understanding of how people perceive fairness and to identify the important factors influence this perception, in order to select the attributes and the attribute levels of the Stated Preference experiment.

The reason for doing individual interviews rather than another focus group is that it was considered a demanding and time-consuming task to gather those groups of people in one place at the same time. Furthermore, it would be difficult to organize, perform and analyze a second Focus Group Discussion given the time span of this study. Therefore, the flexibility of this method was the main reason for choosing it.

4.2.1. Preparation and Execution of Interviews

The format of the Individual Exploratory Research Interviews follows the one of the Focus Groups Discussion, with the only difference that it is conducted separately for each respondent. This means that the questions for the interview questionnaire have been formulated based on the Focus Group questions, that have been discussed above, and the feedback from the pilot session. The questionnaire that has been used for the interviews can be found in *Appendix C*.

Since the Focus Group session has been already conducted and analysed, it was decided that there is not a specific number of interviews that need to be conducted, but rather conduct them until it seems that there is no more added-value information compared to the Focus Group discussion findings or any of the previous interviews. The individual interviews took place between 28th of May and 3rd of June, and 4 respondents participated in total. The average time of an interview was approximately 15 minutes. The characteristics of the respondents can be found in the following table.

Table 4 – Characteristics of Individual Exploratory Research Interviews participants

No.	Gender	Age group	Maximum level of education completed
1	M	36-45	College / University
2	M	46-55	College / University
3	F	46-55	College / University
4	M	56-65	College / University

4.2.2. Data Analysis and Findings

First of all, as mentioned above, only 4 respondents participated to this part of the preliminary research. The reason for that was that firstly, the interviews were supplementary to the focus group discussion, and secondly that the last two interviews provided no new information or insight compared to the first two previous ones. Moreover, the fact that the participants were not interacting with other people in the form of a conversation limited the insights they were providing. In general, most of the answers of the participants were of a similar nature with those from the focus group. However, some new insights came up from those individual interviews.

One finding similar to the ones from the focus group is that all 4 participants think that it is not fair to remove the freedom of specific age groups to drive in order to increase safety, because you reduce the mobility of those groups. That means that they though it is unfair that only specific age groups get the negative externalities of a policy for others to gain safety. Thus, it is important to explore how the negative externalities are distributed across the different age groups.

In addition to the findings of the Focus Group session related to “who pays” for the monetary costs to implement a road safety policy, what has been concluded from the interviews is that not only it is important whether the users pay or the costs are subsidized by the government, but also how those cost are distributed to the users or tax payers compared to their income. Thus, it is important to consider the aspect of the way that the monetary costs are distributed among the different income groups.

Finally, one of the most important findings of the individual interviews is that, as one participant mentioned, *“If you have a high number of fatalities you care less about fairness. You just want to reduce them as much as possible”*. In other words, the higher the current number of fatalities the more people focus on effectiveness rather than fairness. Hence, it can be easily assumed that the current level of fatalities does play a role in how much people are willing to trade-off between distributional fairness and effectiveness. For that reason, the current level of fatalities will be included in the Stated Preference experiment in order to observe to what extend this assumption might be true.

4.3. Conclusions from Preliminary Research

In this section, the main conclusions from the outcomes of the two preliminary data collection methods and how they are going to help design the Stated Preference Experiment are presented. In total, 10 respondents participated in the preliminary research. As mentioned before, the main aim of this preliminary research was to identify the important attributes that will be included in the Stated Preference experiments, which is discussed in the next chapter.

Firstly, the main conclusions regarding the aspects related to the first two dimensions of distributional fairness, namely which effects are to be distributed and how is the population categorized, are going to be presented. This way it is possible to connect people’s perception of distributional fairness with the existing equity theories that can be found in the literature (see *Section 2.6*). After that, the other factors that are not directly related to the distribution of effects have been identified and are going to be presented. Those factors have been categorized into personal characteristics and policy-related characteristics. Finally, the main aspects that are traded-off against the perceived distributional fairness have been identified and are going to be presented.

As regards the factors related to the distribution of effects, these can be categorized in two major groups. The first category is related with the distribution of the benefits. In this category, three aspects have been identified to affect the perception of distributional fairness of a policy. One aspect is the distribution of the benefits to the different road user categories, or in other words the vertical equity between different road users based on their vulnerability. A second aspect is the spatial distribution of the benefits to different areas of interest and is closely related to the concept of spatial equity. The third and final aspect is the distribution of the benefits to different age groups, which is a form of social equity since personal characteristics are included in the analysis.

The second big category is related to the costs of the road safety benefits. Those costs can be further categorized into two groups. The one consists of the monetary costs to implement the policy, while the other consists of non-monetary negative externalities, like reduction of accessibility and mobility, or increase in travel times. As regards the monetary costs, two aspects have been found to play a significant role. These aspects are the distribution of the costs to the different types of road users and the distribution on different income groups. However, slightly different aspects have been found as regards the non-monetary negative externalities. Those are the distribution to the different age groups, and as with the monetary costs the distribution to the different road users.

The following figure (Figure 11) presents a graphical representation of all the aspects that have been identified to affect people's perception and are related to the first two dimensions of the perceived distributional fairness (i.e. which effects are distributed and how is the population categorized).

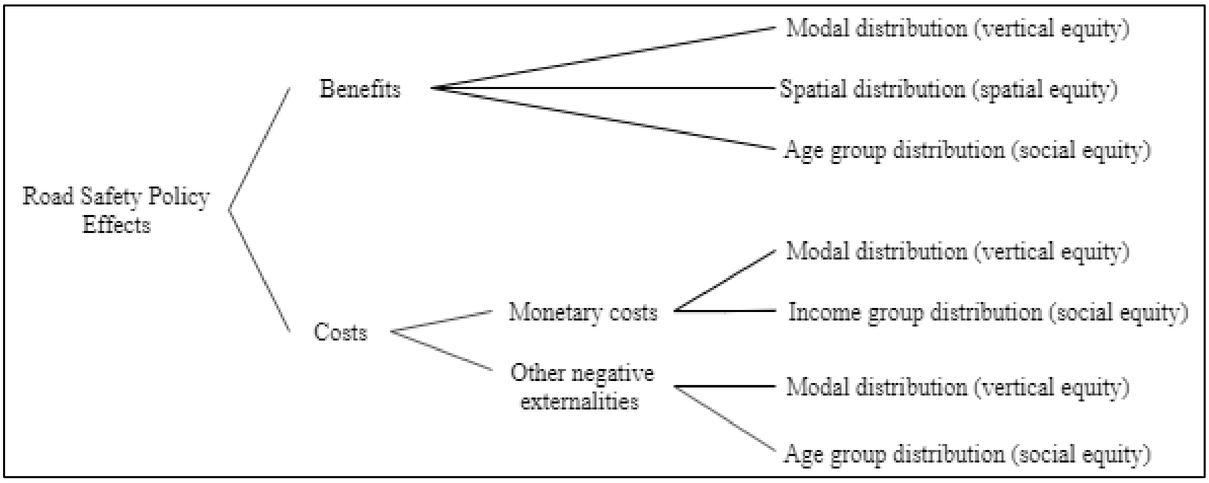


Figure 11 – Important aspects related to the distribution of effects of road safety policies

However, as mentioned above, there are more factors that have been found to potentially influence the perception of fairness and are not directly related to the distribution of effects. Those factors have been categorized in two major groups. The first category is related to personal characteristics, other than the usual ones that are used in Stated Preference experiments, such as age, gender etc. The one personal characteristic that influences the perceived distributional fairness is the most frequently used mode of transport. On the other hand, the second category is related to characteristics of the road safety policy itself. The potential factors that have been found from the preliminary research are the type of the policy (e.g. infrastructure related or regulation related policy), the scale of the focus area (such as neighbourhood, urban area, province, national), and the procedure that has been followed during the design and decision-making phase (e.g. level of participations of people).

As regards the later, this aspect is not directly related to the concept of distributional justice. It is rather related to the procedural justice, which as mentioned in *Section 2.6*, affects the perception of people regarding distributional justice. For that reason, it might be important to include this aspect in the design of the experiment since if the procedure is conceived as more fair by people then the perception of distributional justice is expected to increase.

Finally, the policy aspects that people consider as potential trade-off aspects with distributional fairness are mainly the effects that are mentioned above, but in absolute levels. More specifically, those aspects are the total monetary costs to implement the road safety policy, the reductions in accessibility (increase in travel times), the current number of fatalities and the total number of reduction of fatalities.

To sum up, the most important aspects that have been identified to influence people’s perception of distributional fairness or have been found to be traded-off against fairness and will be later translated into attributes for the Stated Preference Experiment are as follows.

Distribution of benefits (Aim of the Road Safety Policy):

- Spatial distribution of the road safety benefits
- Distribution of the road safety benefits on the different road user types
- Distribution of the road safety benefits on the different age groups

Distribution of monetary costs:

- Distribution of the monetary costs on the different road user types
- Distribution of the monetary costs on the different income groups

Distribution of the non-monetary negative externalities (e.g. reduction in accessibility and mobility, increase in travel times etc.):

- Distribution of the non-monetary externalities on the different road user types
- Distribution of the non-monetary externalities on the different age groups

Aspects that are traded-off with the perception of distributional fairness of road safety policies:

- Absolute level of monetary costs
- Absolute level of reduction in fatalities
- Absolute level of non-monetary negative externalities (accessibility, mobility, travel times etc.)

Other non-distributional related aspects that might affect people's perception of distributional fairness, or the extent up to which they are willing to trade it with other aspects of road safety policies are:

- Policy nature aspects:
    - Type of road safety policy (see *Section 2.1*)
    - Scale of the geographical focus area of the road safety policy
    - How are the monetary costs paid (paid directly by the road users or by government via taxation)
    - Level of participation of different groups of citizens in the design and decision-making process

- Personal characteristics:
    - Most frequently used mode of transport

- Other relevant factors:
    - Current level of fatalities

5. Experimental Design

After gathering all the necessary information from the preliminary research, the design of the main experimental method follows. This chapter describes the design process of the Stated Preference experiment. More specifically *Section 5.1* describes the attribute and attribute level selection and *Section 5.2* describes the experimental design process. Finally, *Section 5.3* presents the final experimental design that will be used in this study.

The first step in order to design both experiments is to select the most appropriate attributes and their attribute levels. The attributes of both the rating experiment and the choice experiments are going to be selected based on the findings of the preliminary research. As mentioned in *Chapter 4*, the influential factors on the people's preferences on distributional fairness of road safety policies can be categorized in the ones related to distribution of effects, policy characteristics, personal characteristics and aspects that are traded-off with distributional fairness. The ones related to the distribution of effects are going to be included in the rating experiments, since they are solely related to the perception of distributional fairness. On the other hand, the traded-off aspects are going to be part of the choice experiment. Finally, personal characteristics like the most frequently used mode of transport, are going to be included in the socio-demographic part of the survey.

Unfortunately, as regards the policy characteristics that influence the perception of distributional fairness, they have been chosen not to be included as attributes in the experiment because they are increasing its complexity exponentially. This is because for every different attribute level that is included, a new choice experiment is necessary, because the different levels would require having different values in the traded-off aspects of the policies, like cost or reduction in fatalities. For example, a different scale of cost values would be required for a national scale policy than for one that focuses in a specific urban area, in order to have realistic alternatives in the choice sets.

For that reason, the policy characteristics were chosen either not to be included or to be fixed in a specific attribute level for both the rating and the choice experiment. Since the aim of this study is to explore the people's preferences from the citizens' perspective, only the aspects related to this matter where chosen to be included. Hence, the context for both the experiments will be "a national road safety policy, where the costs are paid from the government via taxation". The type of the policy and the level of participation of people are not going to have an added-value contribution to this study if they are included as a fixed value.

5.1. Attributes and Attribute Levels Selection

5.1.1. Distributional Fairness Perception Experiment

As mentioned above, only the aspects related to the distribution of road safety policy effects are going to be included as attributes in the rating experiment. In order to include them they first need to be translated into attributes and to select their necessary attribute levels. For each attribute there will be an attempt, when possible, to connect the attribute levels with the ethical theories of *Section 2.6*, but also keep the choices as simple and realistic as possible, based also on findings from the preliminary research, in order to be clear for the respondents that have no background knowledge on the topic. Below all the relevant attributes of the rating experiment and their attribute levels are presented.

Attributes related to the distribution of road safety benefits (or Aim of the policy):

<u>1. Spatial distribution</u>

This attribute is a nominal attribute related to the concept of spatial equity. Each level represents one type of spatial distribution of the road safety benefits which is related to a distributive justice principle. The three attribute levels that are included in the experiment and are based on the preliminary research and the justice principles are as follows.

1. The reduction in the number of road fatalities is distributed to the different regions proportionally to their current number of road fatalities. This way the policy will aim to reduce the inequalities between the different regions of the country. (Egalitarian theory)
2. The reduction in the number of road fatalities is distributed only to the most disadvantaged regions of the country, in terms of current number of road fatalities. The road safety needs of the other regions play no role in the decision. (Rawl's Egalitarianism)
3. The reduction in the number of road fatalities is distributed equally to the different regions of the country regardless of their characteristics. (Equal shares distribution)

Since this attribute is a nominal attribute, this means that it needs to be dummy coded. Therefore, for each attribute level, a different parameter will be estimated, in order to calculate the contribution of each level compared to the reference level. In this case the reference level has been chosen to be the third level, i.e. the equal treatment of all regions.

<u>2. Distribution on different road users</u>

For the distribution of road safety benefits on the different road user categories things are more complicated. First of all, there is a large number of categories of road users that has been identified. Those are pedestrians, disabled, cyclists, motorcyclists, public transport users and car users. Moreover, from the preliminary research, it has been concluded that people focus on the road safety users in terms of vulnerability and risk exposure. That mean that in order to explore the vertical equity of road users they need to be ranked in terms of vulnerability and then observe how the most disadvantaged users are treated by expressing the attribute levels based on different justice principles like above.

However, in road safety policies this does not include all the possibilities, since the aim of a road safety policy is not always focused on the most disadvantaged users, thus it is not logical to evaluate it only in that term. For example, one road safety policy might aim only to reduce the fatalities of car users. For that reason, it is more preferred to explore the preferences of people on setting the different road users as the priority of the road safety policy. In order to reduce the number of the attribute levels in a more reasonable number, thus make it less complicated for the respondent, and to be more realistic, it has been chosen to include the vulnerable users, namely pedestrians, disabled, cyclists, and motorcyclists as one group. This was based also on the findings of the preliminary research, where people often referred to them as one category.

Based on all the aforementioned reasons, it has been chosen to formulate this attribute as a nominal attribute that will be dummy coded and each level represents the following.

1. Road safety policy aims to reduce fatalities of vulnerable road users
2. Road safety policy aims to reduce fatalities of public transport users
3. Road safety policy aims to reduce fatalities of car users
4. Road safety policy aims to reduce fatalities of all road users equally

By setting the attribute levels this way it is assumed that the benefits of the road safety policy, i.e. the reduction of the fatalities, is allocated only to one group of road users. For each attribute level, a different parameter will be estimated, in order to calculate the contribution of each level compared to the reference level. In this case the reference level has been chosen to be the equal treatment of all road users. This way the preference for focusing on each group compared to not focusing on any group can be estimated.

3. Distribution on different age groups

A similar approach as the above has been also followed in this attribute. Since people seemed to have different opinions about young drivers and elderly drives in the preliminary research, it is interested to explore what would be the contribution in the perception of distributional fairness if the policy would focus on specific age groups. For that reason, the attribute has been formulated as a nominal attribute that will be dummy coded and each level represents the following.

1. Road safety policy aims to reduce fatalities of young age groups
2. Road safety policy aims to reduce fatalities of elderly
3. Road safety policy aims to reduce fatalities of all age groups equally

By setting the attribute levels this way it is assumed that the benefits of the road safety policy are allocated either to only one of those age group or to all age groups equally. For each attribute level, a different parameter will be estimated, in order to calculate the contribution of each level compared to the reference level. In this case the reference level has been chosen to be the equal treatment of all age groups. This way the preference for focusing on each age group compared to not focusing on any group can be estimated.

Attributes related to the distribution of the monetary costs to implement the policy:

<u>1. Distribution on different road users</u>

For the formulation of this specific attribute, a different logic has been followed compared to the ones above. Since this attribute is going to be combined with the next one, which is related to income, it is not realistic that the costs of a policy are allocated to the public transport users based on their income. And since most public transport systems are subsidized by the government it is not realistic to assume imposing a tax on those users. Also, it is considered not too realistic to assume that the monetary costs are paid only by the vulnerable road users. Hence, only two levels are going to be included in this attribute and are as follows.

1. Monetary costs are paid by the car users
2. Monetary costs are paid by all road users

<u>2. Distribution on different income groups</u>

As regards the distribution of the monetary costs to implement the road safety policy to the different income groups, three attribute levels are going to be included in the experiment. These three levels have been chosen based on some basic types of tax systems (e.g. proportional and progressive), and also because they were considered logical to be included as attribute levels, keeping also in mind the justice principles and that they need to be simple so that respondents can understand them. The three attribute levels that describe the different types of distribution of the monetary costs, are as follows.

1. Monetary costs are distributed equally (in absolute values) to all income groups. Everyone pays the same amount of money.
2. Monetary costs are distributed proportionally to income. Each person pays the same percentage of their income. The more the road users earn the more they have to pay in absolute terms.

3. Monetary costs are distributed progressively to different income groups. Higher income groups are contributing a larger percentage of their income. The more road users earn the bigger percentage of their income they have to give. This attribute has been design based on the progressive tax system that is followed in several countries, like the Netherlands.

This attribute has been also formulated as a nominal attribute thus need to be dummy coded too. For each attribute level, a different parameter is estimated, in order to calculate the contribution of each level compared to the reference level. In this case the reference level has been chosen to be the equal treatment of all road users. This way the preference for allocating the cost only to specific groups can be estimated, compared to allocating them to all group of road users equally.

Attributes related to the distribution of the non-monetary negative externalities (e.g. reduction in accessibility and mobility reduction or increase in travel times):

1. Distribution on different road users

Again, by following the same reasoning as in the distribution of road safety benefits and monetary costs to the different road user categories, it was chosen to formulate this attribute as a nominal attribute that will be dummy coded and each level represents the following.

1. Non-monetary externalities are allocated to the vulnerable road users
2. Non-monetary externalities are allocated to the public transport users
3. Non-monetary externalities are allocated to the car users
4. Non-monetary externalities are allocated to the all road users equally

By setting the attribute levels this way it is assumed that the non-monetary negative externalities of the road safety policy, i.e. travel time increase, reduction in mobility and accessibility, are allocated only to one group of road users. For each attribute level, a different parameter is estimated, in order to calculate the contribution of each level compared to the reference level. The reference level has been chosen to be the equal treatment of all road users. This way the preference for focusing on each group compared to not focusing on any group can be estimated.

2. Distribution on different age groups

Similarly to the distribution of benefits, it is interesting to explore what would be the contribution in the perception of distributional fairness if the non-monetary negative externalities are all allocated on a specific age group. For that reason, a nominal attribute will be included, that will be dummy coded and each level represents the following.

1. Non-monetary externalities are allocated to the young age groups
2. Non-monetary externalities are allocated to the elderly
3. Non-monetary externalities are allocated to all age groups equally

Yet again, by setting the attribute levels this way it is assumed that the negative externalities of the road safety policy are either allocated only to one of those two age groups or equally to all age groups. For each attribute level, a different parameter is estimated, in order to calculate the contribution of each level compared to the reference level. The reference level has been chosen to be again the equal treatment of all age groups. This way the preference for focusing on each age group compared to not focusing on any group can be estimated.

5.1.2. Road Safety Policy Choice Experiment

In the choice experiment, the attributes that are going to be included are related to the aspects that are traded-off with distributional fairness. In order to include those aspects in the design they need to be translated into attributes and also to select the most appropriate attribute levels, as it has been done with the rating experiment. For each attribute there will be an attempt to keep the choices as simple and realistic as possible in order to be clear for respondents that have no background knowledge on the topic. Below all the relevant attributes of the choice experiment and their attribute levels are presented.

<u>1. Monetary Costs</u>

The first attribute is associated only with the monetary costs required to implement a road safety policy. As mentioned above, no context variables will be included related to the type or scale of the policy, because this will require different attribute levels for each type and scale level. Thus, the attribute levels will be selected in order to be realistic for all types of national policies (since the policy scale will be fixed on the national level).

To ensure that the attribute levels which will be used are going to be realistic for all types of policies the average cost to implement the 24 measures of the start-up program of Sustainable Safety vision is going to be used. To implement the start-up program in 1998 a subsidy of 110 million € has been given by the Dutch government. This results in an average of around 5 million € per road safety measure. This average value will be used as the middle attribute level value.

Furthermore, a higher and a lower value will be used in order to observe how and to what extent a higher or lower implementation cost would affect the preferences of citizens over different road safety policy options. Based on the report of Yannis, Evgenikos, & Papadimitriou (2008) there is a wide variety of safety measures that have a cost of around 1 million €. Thus, this price has been selected to be the lower attribute level value for cost. In order to have the same difference between the three levels, the highest level needs to be 10 million €. To sum up, the three attribute levels for the cost attribute are going to be 1, 5 and 10 million €.

2. Effectiveness

As mention in *Chapter 2*, the effectiveness of a road safety policy is mostly measured in terms of the total reduction in road fatalities for the period that the policy has been implemented. However, in this study effectiveness will be described in terms of reduction in road fatalities per year. The main reason to do so, is that this study does not aim to examine a specific type of road safety policies, and according to Weijermars et al. (2011) when implementing the "Sustainable Safety" program, it was assumed that different policies have different time spans. For example, as they mention in their analysis the infrastructure related measures are assumed to have a time span of 30 years, while vehicle related measures have 10 years, and public campaigns only 1 year. Thus, for this study it is not possible to compare policies generally on the total reduction, but it is preferred to use the reduction in fatalities per year, in order to have a more fair comparison.

However, even with the same time span, different types of road safety policies have a different number of reduction of road fatalities (Weijermars & Wegman, 2011). In order to select attribute values that will be realistic and applicable for all types of road safety policies, it was chosen to use values based on the aggregate total reduction in fatalities in the 10-year period of 1998-2007 and of the year 2007 as they are referred in Weijermars et al. (2011). Based on this study, the 24 road safety measures of Sustainable Safety resulted in avoiding 1600-1700 road fatalities in the period 1998-2007 and of 300-400 for the year 2007. This results in an average of 7 road fatalities per road safety measure per year and 13-17 per road safety measure per year, respectively.

Moreover, Elvik (2009) has made an estimation of the expected first order effects of several road safety measures in Norway for the year 2020. Most safety measures are expected to have a range between 0 and 5 fatalities saved and only a few are expected to have more than 15. Based on the two aforementioned studies the attribute levels were chosen to be 5, 10 and 15, in order to be as close to those expected values and as realistic as possible for all types of road safety policies.

3. Non-monetary externalities

This attribute describes the aggregate level of non-monetary externalities of the road safety policy, i.e. reduction in mobility and accessibility or increase in travel times. For this experiment it has been chosen to express this attribute only in terms of increase in travel times. Increase in travel times is believed to be more clear and easily perceived concept to the participants than vaguely describing the reductions in mobility or accessibility. Thus, in order to increase the simplicity of the experiment, this attribute has been chosen to be expressed in three levels describing the average increase of travel times per day, similarly to Mouter et al. (2017). As mentioned in *Chapter 2*, Mouter et al. (2017) is one of the first studies that attempted to include equity considerations in road safety policies. Based on this study the three attribute levels have been selected to be 5, 10 and 15 minutes of average increase of travel times per day.

4. Perceived Distributional Fairness

Perceived Distributional Fairness is the attribute that links the choice experiment with the rating experiment. As mentioned before, it is going to be included in the choice experiment design as an attribute for which the values are determined by a statistical design. The attribute levels of Perceived Distributional Fairness are chosen to be the extreme values 1 (Unfair) and 5 (Fair) together with the median value 3 (Neutral).

5.2. Experimental Design Process

After deciding upon the attribute and the attribute levels of each experiment, the Ngene software (ChoiceMetrics, 2012) is used in order to generate their experimental designs. A large experimental design can potentially result in fatigue, which can lead to either the respondents quitting the survey or randomly answering the questionnaire providing this way unreliable data. For this study the preferred number of tasks per respondent has been chosen to be around 10-12 rating and 10-12 choice tasks. In case that more than this optimal number of tasks is required for the experimental designs then they will be split into blocks that will be randomly distributed to the respondents.

For both experiments an orthogonal fractional factorial design will be attempted to be generated. The orthogonality of the experimental design ensures the attribute level balance of each attribute and that all parameters can be estimated independently due to lack of correlation (ChoiceMetrics, 2012). The next two subsections describe the process to generate the experimental designs of both the rating (*Section 5.2.1*) and the choice experiment (*Section 5.2.2*).

5.2.1. Rating Experiment Design

In total the rating experiment consists of two 4-level attributes, four 3-level attributes and one 2-level attribute (see Table 5). In order to estimate the model parameters for these attributes a minimum of a total of 15 degrees of freedom is required. Therefore, a minimum of 16 profiles is necessary to be included in the experimental design. For simplicity reasons only the main effects of the attributes are included in the design and not the interaction effects between them, since this would result in a very large design.

Moreover, in this specific case in order to ensure the orthogonality of the experimental design a minimum of 36 profiles is required. Thus, a main effects only orthogonal fractional factorial design is going to be generated using the Ngene software package, that results in a total of 36 rating tasks. Due to the orthogonality of the design there is no correlation between the attributes.

As mentioned above, the optimal chosen maximum number of rating tasks per respondent is around 10-12. For that reason, the 36 profiles are divided in 3 blocks of 12 profiles, and every respondent will answer only one of those blocks. Blocking the experimental design ensures that attribute level balance is still satisfied and thus respondents do not come across only with the low or high attribute levels of a specific attribute. The Ngene code syntax that has been used can be found in *Appendix D*, while the generated experimental design in *Appendix E*.

Table 5 – Rating experiment attributes and attribute levels

Attributes	**Levels**
Road Safety Benefits	
Spatial Distribution	1. Proportionally to fatalities
	2. Only to disadvantaged
	3. Equally
Distribution to modes	1. Focus on vulnerable road users
	2. Focus on public transport users
	3. Focus on car users
	4. Focus on all road users equally
Distribution to age groups	1. Focus on young age groups
	2. Focus on the elderly
	3. Focus on all age groups equally
Monetary Costs	
Distribution to modes	1. Paid by car users
	2. Paid by all road users
Distribution to income groups	1. Distributed equally to all income groups
	2. Distributed proportionally to income
	3. Distributed progressively to income
Non-monetary Externalities	
Distribution to modes	1. Allocated to vulnerable road users
	2. Allocated to public transport users
	3. Allocated to car users
	4. Allocated to all road users equally
Distribution to age groups	1. Allocated to young age groups
	2. Allocated to the elderly
	3. Allocated to all age groups equally

5.2.2. Choice Experiment Design

In total, the choice experiment consists of four 3-level attributes (see Table 6). In order to estimate the model parameters for these attributes a minimum of a total of 8 degrees of freedom is required. Therefore, a minimum of 9 profiles is necessary to be included in the experimental design. However, in order to ensure the orthogonality of the experimental design a minimum of 12 profiles is required.

Table 6 – Choice experiment attributes and attribute levels

Attributes	**Unit**	**Levels**
Cost	Million Euro	1, 5, 10
Effectiveness	Fatalities saved	5, 10, 15
Non-monetary externalities	Minutes of average travel time increase	5, 10, 15
Distributional fairness	Perception rating from 1 to 5	1, 3, 5

Each profile of the experimental design consists of two road safety policy alternatives. The respondents will have to choose over one of those two. However, before generating the experimental design it is important to consider that according to literature fairness is assumed to be an important aspect for citizen, and thus can constitute a show-stopper for policies. For this reason, a “none of the above” option needs to be included in each choice set. Generally, the second characteristic of discrete choice modelling, i.e. each respondent must choose one of the two alternatives, is not restrictive which makes it possible to add this choice.

One disadvantage of adding the “none of the above” option is that if a large number of respondents choose this option, then it is not possible to estimate a model. To avoid this problem the “none of the above” option will be added as a separate question. First, the respondent will have to select one of the two alternatives. Then a second question will follow, asking the participants whether they would actually suggest the government to implement this policy. This way it is possible to estimate the model and also give a no-choice option to the participants, in case they think that both alternatives should not be implemented because they are unfair.

However, asking directly the participants to say if they would actually recommend the policy option, they have just chosen, to the government imposes the risk that they will try to defend their own choice. To avoid this risk, the questions will be formulated in an indirect manner. Participants will be, thus, asked whether they would vote in favour of that option in a referendum hosted by the government because it was considering of adding it to its current road safety policy program. By following this approach, the aforementioned risks have been mitigated and the assumption about fairness consisting a show-stopper for policies can be examined.

Furthermore, based on the assumption that fairness consists a show-stopper for policies it can be easily further assumed that people might be willing to exchange fairness with other aspects of the policies only up to some extent. After a specific threshold of unfairness people would not accept compensation by increasing the other attributes. Thus, to observe this the interaction effects between fairness and the rest of the observable policy attributes need to be included in the experimental design. This means that 3 more parameters are going to be estimated adding this way 3 more degrees of freedom, resulting in a total of 11 degrees of freedom. Thus, the 12 profiles to generate an orthogonal fractional factorial design are sufficient to include the interaction effects too. Due to the orthogonality of the design there is no correlation between the main effects of the attributes.

Finally, as mentioned before, the current level of fatalities will be added as a context variable on each choice task. It is added in the experiment because of the assumption that the current level of fatalities plays a role in how much people are willing to trade-off between distributional fairness and effectiveness, and that the higher the current number of fatalities the higher the importance of the effectiveness of the road safety policy. This context variable will vary in 3 levels, which means that three times more profiles are required to be used in the experiment. In order to have realistic levels the most recent accident data related to road accidents in the Netherlands are used. The total number of road fatalities in the Netherlands in 2018, according to SWOV (2019) was 678 persons. Based on that, the three context variable levels have been chosen to be 400, 700 and 1000 road fatalities, in order to have the middle value closest to the real value of the accident data, and thus observe how a higher or lower value in terms of road fatalities affect people's preferences.

Since the existence of this context variable requires three times more profiles and the generated design consists of 12 profiles, the total number of choice tasks that needs to be used is 36. This requires splitting those 36 tasks into 3 blocks of 12 profiles each, which is a more desirable number of tasks. To create these 3 choice experiment blocks and to ensure that all context variable levels are presented to every respondent the following steps have been followed. Firstly, the generated design of 12 profiles has been divided into 3 initial blocks of 4 profiles. Each block was assigned a different context variable level. These three initial blocks combined consist the first block of the choice experiment. This process has been repeated two more times assigning different context variable levels on each block every time (see Table 7).

Table 7 – Context Variable Levels in Choice Experiment Blocks

Choice Experiment Block	**Context Variable Level per Initial Block**		
	Initial Block 1	**Initial Block 2**	**Initial Block 3**
Final Choice Block 1	400	700	1000
Final Choice Block 2	700	1000	400
Final Choice Block 3	1000	400	700

However, the last step before finalizing the choice experiment part of the questionnaire is to check the plausibility of all the choice sets that have been generated in order to ensure that there is no choice set that includes a dominant alternative. Choice sets that have dominant alternatives offer no information on trade-offs, thus it is preferable to either make small changes in the experimental design or to not include those choice sets in the questionnaire at all. Both solutions add correlations between the attributes.

After a series of manual adaptations of the design trying to eliminate as less as possible dominant alternative choice sets and also keeping the correlations as low as possible, a final experimental design has been created. This required, firstly to change the levels of some attributes of the profiles in order to have fewer dominant alternatives and secondly to keep the correlations between alternatives as low as possible. Then the remaining choice sets that included a dominant alternative were excluded from the design. This results in a final experimental design consisting of 8 choice sets. The Ngene code syntax that has been used can be found in *Appendix D*, while both the initially generated and the final experimental designs can be found in *Appendix E*.

5.3. Pilot Survey

The first block of each experimental design has been used in a pilot survey in order to test the clarity of the questions. Moreover, two different representations of the profiles of the rating experiment are going to be tested in order to use the most efficient one. The first version (Figure 12) consists of an explanation through text, in order to give the information as explicitly as possible, and thus avoid possible misunderstanding or vagueness that would lead to participants making assumptions. The second considered representation (Figure 13) consists of one table where the level of each attribute is presented separately, and further explanation is provided via a hypertext when necessary.

Road Safety Policy 1:
The aim of the policy is to reduce the number of fatalities of **all** road users of **all** age groups **equally on all regions** of the country.

The costs are paid by the government with a tax imposed **proportionally** on all **car** users. Everyone will have to pay the **same percentage** of their income.

With this road safety policy the average travel time of **all** road users is increased **equally** and the mobility of **young** age groups is reduced.

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Figure 12 – Example of the text alternative design representation for the rating experiment profiles

Road Safety Policy 1:

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Figure 13 – Example of the table alternative design representation for the rating experiment profiles

In total, six respondents participated in the pilot survey. Each of them has been randomly assigned one of the two version of the questionnaire. While answering it they were also asked to write some feedback in order to improve the instructions and the questions. After finishing the questionnaire, the participants were shown the alternative version of the questionnaire and where asked to comment on whether the profiles are more easily understood that way and if they would prefer to have been given this one instead.

From this pilot survey, it has been concluded that the table version is more clear than the text version. All three participants that answered the text version stated that it was quite demanding and required to re-read the sentences a few times to fully gasp their meaning due to the large amount of information presented, and that they preferred the table version instead. On the other hand, the participants that were presented the table version stated that the questionnaire was clear, and that they would not prefer the text version.

Based on the findings of the pilot survey, regarding the two considered versions of the rating task, and the general feedback on the clarity of the instruction and the questions, the final questionnaire to be used in the survey has been formulated. The formulation of the final survey questionnaire is discussed more extensively in the following section.

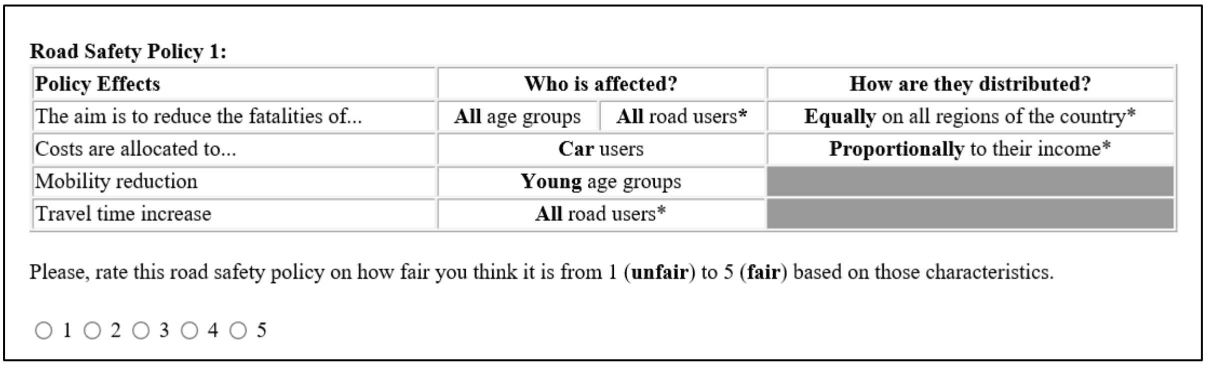
5.4. Final Survey Questionnaire Formulation

As mentioned before, both experiments consist of three different blocks. This means that at least three different versions of the questionnaire need to be formulated. Each respondent will be randomly allocated with one version of the questionnaire, which will consist of one rating experiment block and one choice experiment block. This means that to create the final questionnaire design each of the blocks of the rating experiment needs to be combined with one of the blocks of the choice experiment. The block combinations that are going to be used to determine the questionnaire versions are as follows.

Table 8 – Questionnaire Versions

Questionnaire Version	Rating Experiment Block	Choice Experiment Block
1	1	1
2	2	2
3	3	3

Each respondent will have to perform a total of 12 rating tasks and 8 choice tasks. Each task represents one of the constructed profiles from the experimental designs mentioned above, which vary from each other in terms of attribute levels. For the rating task all the profiles have been constructed based on the table version that has been used in the pilot survey, and is shown in Figure 14 below. On the other hand, the different alternatives of the choice task profiles together with the opt-out question are presented in Figure 15.



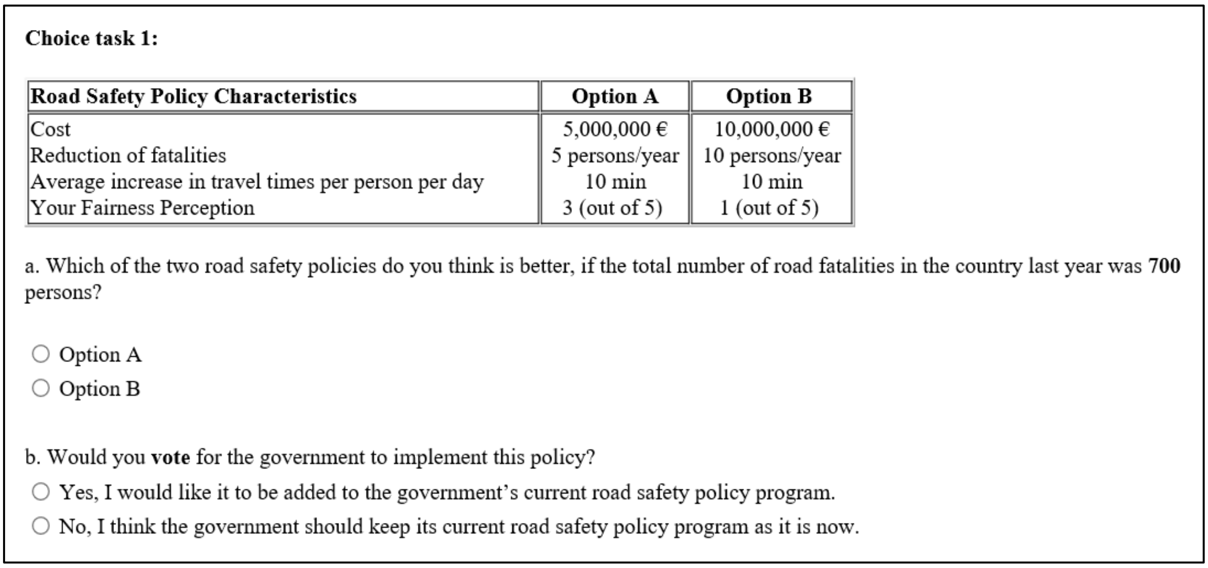
Road Safety Policy 1:

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Figure 14 – Rating task profile example



Choice task 1:

Road Safety Policy Characteristics	**Option A**	**Option B**
Cost	5,000,000 €	10,000,000 €
Reduction of fatalities	5 persons/year	10 persons/year
Average increase in travel times per person per day	10 min	10 min
Your Fairness Perception	3 (out of 5)	1 (out of 5)

a. Which of the two road safety policies do you think is better, if the total number of road fatalities in the country last year was **700** persons?

○ Option A
○ Option B

b. Would you **vote** for the government to implement this policy?

○ Yes, I would like it to be added to the government's current road safety policy program.
○ No, I think the government should keep its current road safety policy program as it is now.

Figure 15 – Choice task profile example

All three versions of the final survey questionnaire that include one of the three experimental design blocks of both the rating and the choice task can be found in *Appendix F*.

5.5. Sociodemographic data gathering

Finally, a third and final part has been added to the questionnaire and consists of several sociodemographic questions. However, in order to respect the rights of the participants to keep their personal data private, the option to avoid giving an answer to the sociodemographic questions is provided. The characteristics that the participants are asked to provide are presented in the following table (Table 9).

Table 9 – Background variables acquired from socio-demographic questions

Background variables
Gender
Age
Nationality
Level of education
Household composition
Household income group
Driver's license ownership
Car ownership in the household
Frequency of use of different transport modes for short distances (e.g. inside urban areas)
Frequency of use of different transport modes for long distances (e.g. to travel to rural areas or between cities)
Frequency of use of different transport modes for commuting

More details on the way that the questions have been formulated can be found in the sociodemographic part of the survey questionnaire in *Appendix F*. As mentioned in *Section 3.5*, the personal characteristics of the participants are going to be measured in order to observe how they affect their perception of fairness and their preferences over different road safety policies. Therefore, the interaction of the personal characteristics with the attributes of both experiments will be tested based on several logical hypotheses that will be formulated below. These hypotheses need to be formulated in order to avoid testing all the interactions, and especially the non-logical ones, that might result in having random interactions that are proven to be statistically significant, but cannot be used to draw logical conclusions.

The logical hypotheses that are examined in the first model for the Distributional Fairness Perception measurement are related to how a specific sociodemographic characteristic might have a positive or negative impact to a specific type of distribution of a relevant equity type. The examined hypotheses are as presented in Table 10.

Table 10 - Initially examined hypotheses for expected sociodemographic variables' effects

1.	An increase to the age of the respondent is expected to have a positive effect on the importance of the distribution of road safety benefits related to the elderly.
2.	If the respondent is a car user it will have a negative effect to the importance of the distribution of road safety benefits to car users.
3.	If respondents have at least one child under the age of 15 in their household, it will have a positive interaction to the importance of the distribution of road safety benefits to younger age groups.
4.	If respondents has at least one person over the age of 65 in their household, it will have a positive interaction to the importance of the distribution of road safety benefits to older age groups.
5.	Car ownership is expected to have a negative effect on the impact of the distribution of monetary costs to car users only.
6.	An increase to the income of respondents is expected to have a negative effect on the impact of the distribution of monetary costs to higher income groups, which are the proportional and progressive distributions.
7.	An increase to the age of the respondent is expected to have a positive effect on the impact of the distribution of non-monetary externalities to the elderly.
8.	If respondents have at least one child under the age of 15 in their household, it will have a negative effect to the impact of the distribution of non-monetary externalities to younger age groups.
9.	If respondents have at least one person over the age of 65 in their household, it will have a negative effect to the impact of the distribution of non-monetary externalities to the elderly.
10.	Being a commuter that uses car as the main mode of transport to go and return from work is expected to have a negative effect to the impact of the distribution of non-monetary externalities to car users only.

In the aforementioned hypotheses several terms are mentioned, which are related to the sociodemographic variables and are based on the collected sociodemographic data. More specifically, for the terms that are used, the operationalization that has been adopted based on the sociodemographic data, is as follows:

- as age, the age group of the individual (1 = 18 - 25 years, 2 = 26 - 35 years, 3 = 36 - 45 years, 4 = 46 - 55 years, 5 = >55 years),
- as income, the income group of the individual (1 = <10,000 €, 2 = 10,000 – 20,000 €, 3 = 20,000 – 30,000 €, 4 = 30,000 – 40,000 €, 5 = 40,000 – 50,000 €, 6 = 50,000 – 60,000 €, 7 = 60,000 – 70,000 €, 8 = 70,000 – 80,000 €, 9 = >80,000 €),
- as car users, the people that did not stated to never use the car for either short or long trips, or to drive to and from work,
- as commuters that use car, the individuals that never use the car to drive to and from work, and
- for car ownership, the definition that has been selected is that this variable take value 1 for individuals that have a car in their household at which they have access to.

Finally, as regards the model estimations for the choice of a Road Safety Policy option since this part of the experiment is related to people’s preferences on how the government should act it is considered difficult to assume that specific personal characteristics might have any interaction with the attributes that are related to the magnitude of an effect that is allocated to the society. Moreover, the personal characteristics of respondents have been already included in the first part of the experiment where the distribution of those effects is described.

The only interaction that seems logical to test is the one between income and the total monetary costs to implement the policy. It is expected that the higher the income of the respondent the bigger the reduction of the importance of cost is. Therefore, it seems logical to include the interactions of income with cost to test this hypothesis.

6. Data Analysis and Results

This chapter describes the steps that followed the formulation of the questionnaire, as described in the previous chapter. Firstly, the data collection process and the descriptive statistics of the sample are presented in *Section 6.1*. Then, the Linear Regression model estimations for the Distributional Fairness Perception experiment is described in *Section 6.2*, while the Multinomial Logistic Regression model estimations for the Road Safety Policy Choice experiment are discussed in *Section 6.3*.

6.1. Data Collection and Descriptive Statistics

The data collection started on the 13th of September until the 5th of October 2019, via "Collector", a data collection platform provided by TU Delft. This platform has been selected as it was the only available option that offers (free of charge) the possibility of a random allocation of different blocks to the participants. The total number or respondents that completed the whole survey questionnaire successfully is 64. As can be seen from the graph below (Figure 16), half of the respondents are from Greece, while 14 of them are from the Netherlands.

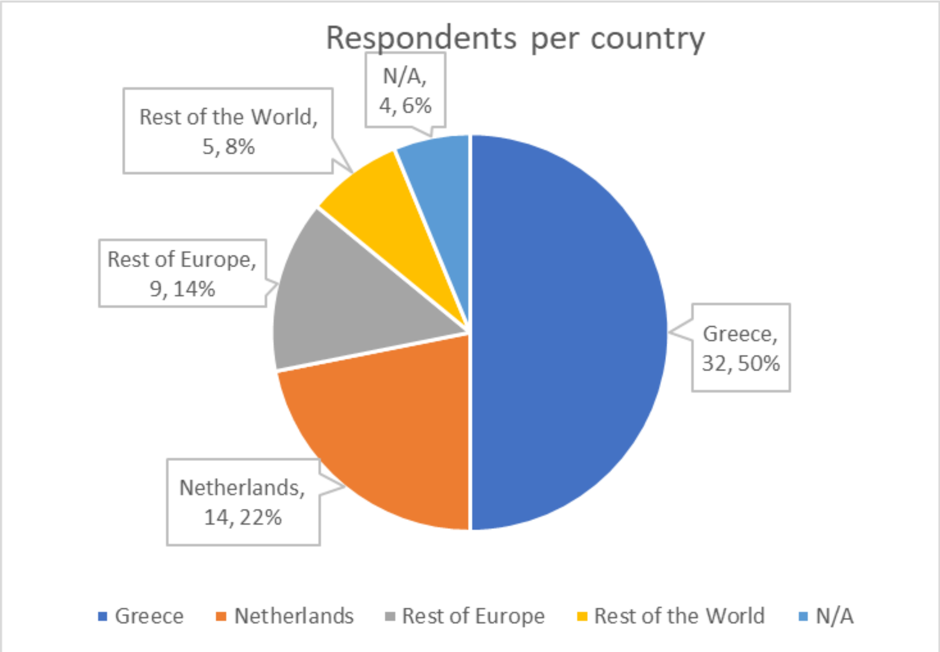


Figure 16 – Number of respondents per country

From those 64 participants, 28% (18 respondents) completed the first block, 42% (27 respondents) the second block, and 30% (19 respondents) the third block. The average time for these respondents to complete the questionnaire was approximately 21 minutes. The following table (Table 11) presents the descriptive statistics of the sociodemographic characteristics of the sample.

Table 11 – Descriptive statistics of the sociodemographic characteristics of the sample

Sociodemographic characteristics	**Categories**	**% of respondents (number of respondents)**
Gender	Male	67% (43)
	Female	31% (20)
	Unknown	2% (1)
Age	18 – 25	24% (15)
	26 – 35	59% (38)
	36 – 45	6% (4)
	46 – 55	3% (2)
	> 55	3% (2)
	Unknown	5% (3)
Education	High School	8% (5)
	Bachelor's Degree	19% (12)
	Master's Degree	69% (44)
	PhD Degree	5% (3)
Driver's License		83% (53)
Car availability		47% (30)
Income	<10,000	14% (9)
	10,000 – 20,000	9% (6)
	20,000 – 30,000	16% (10)
	30,000 – 40,000	9% (6)
	40,000 – 50,000	8% (5)
	50,000 – 60,000	6% (4)
	60,000 – 70,000	3% (2)
	70,000 – 80,000	6% (4)
	> 80,000	9% (6)
	Unknown	19% (12)

In addition to looking at the characteristics that describe the sample it is also important to have a first look at the responses of this sample. By having a quick look at the responses of the participants before diving into the data analysis, several initial conclusions can be drawn that will assist with the analysis and the interpretation of the results that are discussed in more detail in the next sections.

Firstly, by looking at the answers on the first part of the experiment regarding the rating task (see *Appendix G*), one interesting observation is that there is a big variation in the answers for most profiles. This big variation in the answers can be an indicator to expect a rather not so good model fit. Another indicator that shows that a not so good model fit should be expected is that the average value of the lowest scored policy is above 2. As mentioned in the previous chapters, the scale has 5 levels, where 1 represent "Unfair" and 5 "Fair". This means that the lowest rated policy is closer to the second lowest level than the actual lowest level of the scale. This is logical, since as mentioned above the unrealistic distributions (such as only vulnerable road users paying the costs) have been omitted, which would have been probably rated with the lowest level of the scale. Therefore, this will probably result in the model not being able to capture adequately that part of the rating scale.

Table 12 – Lowest and Highest Scored Road Safety Policies

Worst Performance	**Best Performance**
Score = 2.2 (± 1.0)	Score = 4.2 (± 1.0)
Attributes:	**Attributes:**
Road Safety Benefits	Road Safety Benefits
Spatial Distribution = Only to disadvantaged	Spatial Distribution = Equal
Distribution to modes = Car users	Distribution to modes = Vulnerable road users
Distribution to age groups = Elderly	Distribution to age groups = All ages
Monetary Costs	Monetary Costs
Distribution to modes = All road users	Distribution to modes = All road users
Distribution to income groups = Proportional	Distribution to income groups = Proportional
Non-monetary Externalities	Non-monetary Externalities
Distribution to modes = Young	Distribution to modes = All age groups
Distribution to age groups = Vulnerable road users	Distribution to age groups = All road users

Finally, as regards the second part of the survey, which consists of the choice task, one interesting observation is that in 148 of the total 512 choice observations, which equals to 29%, the status-quo has been preferred over both road safety policy alternatives. Therefore, it is expected that there is a utility for the status-quo that both policies need to exceed in order to be picked. By fixing the utility of the status-quo to zero, this preference can be measured using a constant (ASC) in the observed utility function of both alternative options. This constant is expected to have a negative utility contribution that polities need to overcome to have a higher probability to be picked by the respondents.

All these observations need to be kept in mind during the analysis in order to ensure that not only the models are estimated correctly, but that they can be also translated to logical conclusions that will allow to provide with concrete policy advices. In the following sections the data analysis and model estimation procedure of the two parts of the experiment are discussed. From the following sections, the first one (*Section 6.2*) presents the Linear Regression model estimation for the Perceived Distributional Fairness of Road Safety Policies, while the second (*Section 6.3*) presents the estimation of the Multinomial Logistic Regression model estimation for the Road Safety Policy choice experiment.

6.2. Distributional Fairness Perception Experiment Data Analysis

In this section the estimations of the Linear Regression models for the Perceived Distributional Fairness of Road Safety Policies is going to be discussed. Before getting into the model estimations it is important to mention one thing. As mentioned before, in order to respect people's right to not provide their personal information, the option of not answering the sociodemographic questions has been provided in the questionnaire. However, in terms of the model estimation this means that responses without this type of data cannot be included in the model estimation process where interaction of the attributes with sociodemographic variables is included.

This results in reducing the sample, which already can be considered quite limited, since not everyone from the 64 respondents provided their sociodemographic information that was asked, for which it would be interesting to test their interaction with the main attributes. For that reason, it was considered preferable to estimate two Linear Regression models. First, a model that includes only the main attributes as have been specified in *Chapter 5*, and second a model including the interaction of sociodemographic characteristics with the main attributes, but with a smaller sample. The analysis for both Linear Regression model estimations was conducted in R (R Core Team, 2014) and the syntaxes can be found in *Appendix H*.

6.2.1. Linear Regression Model

In this section the first Linear Regression model estimation is discussed. In this model only the main attributes as defined in Table 5 are going to be included in the model estimation. All of the main attributes are nominal, which means that they are going to be dummy coded and a different parameter needs to be estimated for each of their level. This results in a Perceived Distributional Fairness model that is described by the following equation:

$$Y = c + \Sigma(\beta SDBi * SDBi) + \Sigma(\beta MDBi * MDBi) + \Sigma(\beta_{ADBi} * ADBi) + \beta MDCi * MDCi + \Sigma(\beta IDCi * IDCi) + \Sigma(\beta_{MDEi} * MDEi) + \Sigma(\beta_{ADEi} * ADEi)$$

Where Y is the Perceived Distributional Fairness score,

c is the regression constant,

βi is the estimated parameter for each level of the dummy coded attributes,

SDB is the spatial distribution of road safety benefits,

MDB is the distribution of road safety benefits to different modes of transport,

ADB is the distribution of road safety benefits to different age groups,

MDC is the distribution of monetary costs either to all road users or only to car users,

IDC is the distribution of costs to different income groups,

MDE is the distribution of non-monetary externalities to different modes of transport,

ADE is the distribution of non-monetary externalities to different age groups.

For each one of the attributes the reference level for the dummy coding has been chosen to be the equal distribution or the allocation to all road users. This means that the beta and consequently the contribution of those distributions is fixed to zero. Therefore, for each attribute level, the difference to the preference over the reference level is estimated. The estimated parameters from the Linear Regression model estimation are presented in Table 13.

Table 13 – Linear Regression Parameter Estimation (n = 64)

Parameter	Estimation	Std Error	t-value	p-value
C	3.122	0.167	18.665	0.000
Road Safety Benefits				
Spatial Distribution (SDB)				
Proportional	0.378	0.101	3.742	0.000
Only to disadvantaged	0.269	0.101	2.664	0.008
Equal (ref.)	0.000			
Distribution to modes (MDB)				
Vulnerable road users	-0.041	0.116	-0.355	0.723
Public transport users	0.044	0.188	0.235	0.815
Car users	-0.364	0.138	-2.636	0.009
All road users (ref.)	0.000			
Distribution to age groups (ADB)				
Young	-0.181	0.101	-1.792	0.074
Elderly	-0.173	0.101	-1.709	0.088
All age groups (ref.)	0.000			
Monetary Costs				
Distribution to modes (MDC)				
Car users	-0.101	0.117	-0.864	0.388
All road users (ref.)	0.000			
Distribution to income groups (IDC)				
Proportionally	0.472	0.101	-2.968	0.003
Progressively	0.299	0.101	1.710	0.088
Equally (ref.)	0.000			
Non-monetary Externalities				
Distribution to modes (MDE)				
Vulnerable road users	-0.427	0.117	-3.659	0.000
Public transport users	-0.437	0.188	-2.327	0.020
Car users	-0.143	0.138	-1.035	0.301
All road users (ref.)	0.000			
Distribution to age groups (ADE)				
Young	-0.303	0.101	-2.995	0.003
Elderly	-0.240	0.101	-2.372	0.018
All age groups (ref.)	0.000			
$R^2 = 0.1115$				

As already mentioned, in this first estimation only the main effects have been included in the model, but not any sociodemographic variables. This model is useful, if one is interested into getting a first impression of the aggregate impacts of the main attributes to the Distributional Fairness perception.

As regards the distribution of the benefits of road safety policies, the most fair spatial distribution has been proved to be the distribution that is proportional to the needs of each region, in terms of current level of fatalities (0.378). When the allocation happens only to the most disadvantaged regions in terms of fatalities, it is considered to be less fair (0.269). However, both types of distributions seem to have a more positive impact to the Perceived Distributional Fairness, compared to the reference level, which is the equal distribution.

When it comes to the allocation of the benefits to the different types of road users, focusing only to the vulnerable road users or public transport users have been proved to be statistically insignificant, and from the small estimation of the betas it can be assumed that probably there is not significant contribution to the fairness perception compared to focusing on all road users. Therefore, those three types of distributions will have a relative similar impact to the perception of fairness. On the other hand, focusing only to reducing the fatalities of car users has been proved to have a significant and relatively large negative impact to the fairness level.

Lastly, the most fair type of distribution for focusing on different age groups, as can be seen from Table 13, the reference level has been proved to be the most fair, since the other two have a negative estimated value. Therefore, when there is no focus on a specific age group, but rather to all age groups equally, it is perceived to be more fair. Focusing either on saving only the younger age groups or only the elderly seems to have a negative impact to the perception of fairness.

As regards the allocation of the monetary costs to implement the road safety policy to the different road user types, it is observed that posing the policy related tax only to the car users has a negative impact to fairness (-0.101) compared to allocating them to all the citizens. Moreover, as regards the allocation of this tax to the different road users based on their income, the proportional distribution seems to be perceived as the most fair (0.472), with the equal distribution to be considered the least fair.

For the non-monetary negative externalities, two dimensions have been considered. The fist dimension, similarly to the road safety benefits and monetary costs, is the distribution to the different modes of transport. In this case, allocating the negative externalities only to a specific mode of transport has a negative impact to the perception of fairness compared to the reference level, which is allocating them to all road users. More specifically, when vulnerable or public transport users receive the negative externalities there is a relatively large negative impact to fairness perception, both compared to the reference and to allocating them only to car users.

6.2.2. Linear Regression Model with Interaction Effects of Sociodemographic Variables

In addition to the previous model, another Linear Regression model is estimated. This model incorporates the interaction effects of the sociodemographic characteristics of the sample. As already mentioned, this approach results in using a smaller sample than the initial one. Moreover, due to the small sample in order to avoid having random interaction effects that would logically make no sense or would be hard to interpret, it has been chosen to include only the interactions based on logical hypotheses, as they have been formulated in *Section 5.5*.

After conducting a number of estimations, the not statistically significant sociodemographic effects were left out, until all the sociodemographic variables that are kept in the model are statistically significant either as a main effect or as an interaction with at least one of the levels of a main attribute. The one that has been proven insignificant were excluded from the model estimation process, since the initial hypothesis that they have an interacting effect with one of the main attributes can be rejected, which means that their β betas are zero.

From Table 10, the hypotheses that have been proven statistically significant are the impact of car ownership to the distribution of monetary costs to the different modes of transport, the impact of income to the distribution of monetary costs to the different income groups, the impact of being a commuter to the distribution of non-monetary negative externalities to the different modes of transport and the impact of having a person below the age of 15 in the household to the distribution of road safety benefits and non-negative externalities to the different age groups. The resulting equation from this process, that describes the Perceived Distributional Fairness model, is the following:

$$
\begin{aligned}
Y = c &+ \Sigma(\beta SDBi * SDBi) + \Sigma(\beta MDBi * MDBi) \\
&+ \Sigma\big((\beta ADBi\ +\ \beta_{ADBi}^{children} * children) * ADBi\big) \\
&+\ \Sigma\left((\beta MDCi +\ \beta_{MDCi}^{car\ ownership}\ * car\ ownership) * MDCi\right) \\
&+ \Sigma\left((\beta IDCi +\ \beta_{MDCi}^{income} * income) * IDCi\right) \\
&+ \Sigma(\beta MDCi +\ \beta_{MDCi}^{commuter} * commuter) * MDEi) \\
&+ \Sigma\big((\beta ADCi +\ \beta_{MDCi}^{children} * children)\ * ADEi\big) +\ \beta_{car\ ownership} *\ car\ ownership \\
&+\ \beta_{income} *\ income +\ \beta_{commuter} *\ commuter + \beta_{children} *\ children
\end{aligned}
$$

Where Y is the Perceived Distributional Fairness score,

c is the regression constant,

β_i is the estimated parameter for each level of the dummy coded attributes,

SDB is the spatial distribution of road safety benefits,

MDB is the distribution of road safety benefits to different modes of transport, ADB is the distribution of road safety benefits to different age groups,

MDC is the distribution of monetary costs either to all road users or only to car users,

IDC is the distribution of costs to different income groups,

MDE is the distribution of non-monetary externalities to different modes of transport,

ADE is the distribution of non-monetary externalities to different age groups,

income refers to the income group of the respondent,

children is a dummy variable that takes the value 1 if individuals have at least one person below the age of 15 in their household,

car_ownership is a dummy variable that take the value 1 if individuals have a car in their household that they have access to, and

commuter is a dummy variable that takes the value 1 if individuals use a car at least once per week to go and come back from work.

Similarly to the previous estimation, for every attribute the reference level for the dummy coding is the equal distribution or the allocation to all road users. The outcomes from the Linear Regression model estimation, including the interaction effects of the sociodemographic variables, are presented in the following table.

Table 14 – Linear Regression Parameter Estimation with Sociodemographic variables (n = 50)

Parameter	Estimation	Std Error	t-value	p-value
C	2.911	0.236	12.310	0.000
Road Safety Benefits				
Spatial Distribution (SDB)				
Proportional	0.361	0.113	3.207	0.001
Only to disadvantaged	0.317	0.113	2.810	0.005
Equal (ref.)	0.000			
Distribution to modes (MDB)				
Vulnerable road users	-0.038	0.130	-0.296	0.768
Public transport users	-0.022	0.211	-0.105	0.916
Car users	-0.413	0.154	-2.664	0.008
All road users (ref.)	0.000			
Distribution to age groups (ADB)				
Young	-0.131	0.119	-1.097	0.273
Elderly	-0.138	0.120	-1.156	0.248
All age groups (ref.)	0.000			
*Distribution to age groups (ADB) *children*				
Young	-0.228	0.374	-0.609	0.543
Elderly	-0.303	0.374	-0.811	0.417
Monetary Costs				
Distribution to modes (MDC)				
Car users	-0.197	0.154	-1.283	0.200
All road users (ref.)	0.000			
*Distribution to modes (MDC) * car_ownership*				
Car users	0.066	0.189	0.352	0.725
Distribution to income groups (IDC)				
Proportionally	0.857	0.218	3.943	0.000
Progressively	0.557	0.216	2.579	0.010
Equal (ref.)	0.000			
*Distribution to income groups (IDC) * income*				
Proportionally	-0.075	0.044	-1.699	0.090
Progressively	-0.052	0.043	-1.197	0.232

Table 14 – Linear Regression Parameter Estimation with Sociodemographic variables (n = 50) (cont'd)

Parameter	Estimation	Std Error	t-value	p-value
Non-monetary Externalities				
Distribution to modes (MDE)				
Vulnerable road users	-0.341	0.154	-2.216	0.027
Public transport users	-0.345	0.225	-1.399	0.162
Car users	0.048	0.174	0.274	0.784
All road users (ref.)	0.000			
*Distribution to modes (MDE) * commuter*				
Vulnerable road users	-0.023	0.292	-0.078	0.938
Public transport users	-0.005	0.290	-0.017	0.987
Car users	-0.506	0.292	-1.773	0.084
Distribution to age groups (ADE)				
Young	-0.336	0.120	-2.792	0.005
Elderly	-0.146	0.120	-1.216	0.224
All age groups (ref.)	0.000			
*Distribution to age groups (ADE) * children*				
Young	0.325	0.376	0.863	0.388
Elderly	-0.563	0.377	-1.495	0.135
car_ownership	-0.287	0.143	-2.009	0.045
income	0.030	0.032	0.949	0.343
commuter (dummy)	-0.010	0.215	-0.046	0.964
children (dummy)	0.926	0.348	2.664	0.008
$R^2 = 0.1722$				

First of all, by taking a look at the R^2 it can be concluded that this model has a better model fit than the previous one. When it comes to the outcomes of the model estimation, for the main attributes that no interaction effect with any of the sociodemographic variables has been included the outcomes of the model are similar to the previously estimated model. More specifically, for those attributes the relevant differences on the impact compared to the reference levels remained similar to the previous model. The only important differences that are observed are related to some attribute levels that were, for example, slightly more important than another attribute level and now are slightly less important than it. Of course, one logical explanation is that for two different samples have been used to estimate the models, hence these small differences in the estimated parameters.

On the other hand, as regards the attributes for which interaction effects with sociodemographic variables are included, there are several interesting outcomes that were not possible to be observed with the previous model estimation. Firstly, for the road safety benefits distribution, one interaction effect has been included, which is that of the allocation of those benefits to different modes of transport with whether the respondent has a person in their household that is below the age of 15. As regards the distribution of the monetary costs, two interactions have been taken into account. The first is the interaction of car ownership with the distribution of those cost to the different modes of transport, while the second one is the interaction of income with the distribution of the costs to the different income groups.

In the first case, of the interaction of having a person below the age of 15 in the household to the impact of the distribution of road safety benefits to the different modes of transport to the fairness perception, it can be observed that the equal distribution is still considered to be more fair that the other two, and that there is also a negative impact on those distributions. Therefore, these respondents consider focusing on saving the younger age groups as more unfair. This observation is contradicting to the initial hypothesis that has been formulated. If the fact the people who have a person below the age of 15 in the household are only 5 out of the 50 respondents it can be assumed that it is probably a random effect that is observed only for this specific sample of respondents, therefore it cannot be considered trustworthy to draw conclusions.

As regards the distribution of monetary costs to the different modes of transport and the interaction effect of car ownership, since both attributes are nominal it is necessary to include the main effects of both attributes, to avoid adding collinearity. Therefore, the impact needs to be considered together with the interaction effect and the main effect of car ownership. For respondents that do not have access to a car the impact of allocating the monetary costs only to car users is -0.197. However, for those who do have access to a car the negative effect in the perception of fairness when allocating the monetary costs only to car users is bigger and is equal to -0.418 (= -0.197 + 0.066 – 0.287).

For the second interaction effect of the distribution of monetary costs to the different income groups both the proportional and progressive distributions have a positive main effect (0.857 and 0.557). However, the interaction of this attribute with income has been taken into account, thus it needs to be considered when interpreting the effects of this attribute to the Distributional Fairness Perception. In this case, an increasing negative impact is observed on those distributions for each income group level increase (-0.075 and -0.052 per income group level increase). As income increases the impact of the two distributions to the fairness perception approaches zero, hence closer to the equal distribution, but it never gets negative. For example, for annual household income higher than 80,000 € (the highest income group) the total impact to the perception of fairness is equal to 0.857 + (-0.075 * 9) = 0.182 for the proportional distribution and 0.557 + (-0.052 * 9) = 0.089 for the progressive distribution.

Lastly, the other two interaction effects that have been included are related to the distribution of the non-monetary negative externalities. The first interaction is between being a commuter that uses the car to go and return from work with the distribution of those effects to the different modes of transport. The second interaction is between having a person below the age of 15 in the respondent's household and the distribution of the negative externalities to the different age groups.

In the first interaction effect, the initial hypothesis that being a commuter would have a negative effect to allocating the negative externalities only to car uses has been proved to be true. More specifically, there is a general negative impact when allocating the negative externalities to vulnerable road users or public transport users, regardless whether the respondent is a commuter that uses car or not, since the interaction with those levels has been proved to be insignificant. As can be seen from Table 14, allocating the negative externalities only to car users has been observed to have a really small (0.047) and statistically insignificant impact to fairness perception. However, being a commuter that uses car has a negative impact (-0.523) to that initial insignificant impact, and an insignificant impact to the other two levels.

Therefore, two conclusions can be drawn from those outcomes. The first is that for commuters that use car, allocating the negative externalities only to car users is considered to be the most unfair of all the distribution types. The second conclusion is that since the main effect of allocating the negative externalities only to car users has been proved to be statistically insignificant, this distribution does not have a significant added-value to the fairness perception compared to the equal distribution for the rest of the users. Also, for commuters that use car the contribution of all distributions is negative in total, compared to the equal distribution. Therefore, the equal distribution can be considered to be the most fair of all the distribution regardless of whether someone uses car or not to go and return from work.

Finally, the last interaction effect is that of having a person below the age of 15 in the respondent's household and the distribution of negative externalities to different age groups. Generally, allocating the negative externalities equally to all age groups has been proved to be considered the most fair distribution regardless of whether the respondents have a person below 15 in their household. However, when the interaction of this sociodemographic variable is taken into account, the outcomes are similar to the ones of this variable with the distribution of road safety benefits to different age groups, which are contradicting to the initial hypothesis.

More specifically, for respondents with at least a person below the age of 15 in their household, there is a positive impact (0.325) on allocating the negative externalities to the younger age groups, which is the exact opposite of what was initially expected. However, this impact as can be seen from the table above, is statistically insignificant. The reason for that is probably, as in the previous case, the low number of respondents (5) that do have a person below the age of

15 in their household, therefore it can be assumed that this might be a random effect that is observed for this specific sample.

6.3. Road Safety Policy Choice Experiment Data Analysis

In this subsection the Road Safety Policy Choice model estimation process is going to be discussed. As it has already been mentioned for this type of models the Discrete Choice Approach is going to be followed, where the RUM is going to be used as a decision criterion. In this part only the systematic utility (V) estimation is going to be discussed, which is expressed with the following formula.

$$Vi = \sum_{m} \beta_m X_{im}$$

In RUM only the differences in utility matter, thus the systematic utility of the “none of the above” option has been fixed to zero, since choosing this option has no added value. However, this require adding a constant in the utility function. This constant expresses the preference of people over the none of the above option, due to other aspects that were not included in the experiment.

As has already been mentioned in the previous chapters, apart from the main attributes two interaction effects are going to be taken into account during the model estimation. The first one is the current level of fatalities, which is added as an interaction effect to the importance of effectiveness of road safety policies, based on the hypothesis that the higher the current level of fatalities, the higher the importance of effectiveness for people (higher utility contribution). The second interaction effect is the one of income with the total monetary costs of policies, due to the expected negative impact of higher income to the importance of cost. From the 64 participants only 52 provided information on the annual gross income of their household, therefore only the observations of those 52 participants are going to be used for the model estimations.

In this study, three different versions of the Multinomial Logit (MNL) model are going to be estimated. First, a simple MNL model including only the main effects of the attributes defined in Table 6. Then, a second model will be estimated where the random taste heterogeneity of individuals is going to be taken into account. Finally, from the first two models, the one that fits best is going to be estimated again, but with the addition of the interaction effects of Perceived Distributional Fairness with the other attributes. As mentioned before, this will be done in order to observe until what point people are willing or not to trade low levels of fairness with any increase or decrease of the other attributes.

The analysis for all the aforementioned choice model estimations was conducted in R (R Core Team, 2014) using the Apollo Package (Hess & Palma, 2019) and the syntax for each model can be found in *Appendix H*.

6.3.1. Multinomial Logit Model

The first model that will be estimated and is presented in this section is the simple MNL model. Based on what is mentioned above the observed utility function that has been formulated is as presented below and the estimated parameters of the model are presented in Table 15.

$$Vi = ASC + (\beta_{COST} + \beta_{COST}^{income} * income) * COSTi + (\beta_{EFF} + \beta_{EFF}^{FAT} * FAT) * EFFi + \beta_{TT} * TTi + \beta_{PDF} * PDFi$$

Where ASC is the constant,

COST is the monetary costs to implement the road safety policy,

EFF is the reduction in the number of fatalities,

TT is the non-monetary negative externalities expressed in travel times increase,

PDF is the Distributional Fairness Perception of individuals,

income is the income level of the individual, and

FAT is the current total number of fatalities in the country

Table 15 – Parameter estimation for MNL model

Parameter	Estimation	Std Error	t-value	p-value
Constant (ASC)	-1.579	0.446	-3.54	0.000
Cost (COST)	0.284	0.126	2.25	0.024
Effectiveness (EFF)	0.320	0.155	2.07	0.039
Negative Externalities (TT)	-0.034	0.092	-0.37	0.710
Perceived Distributional Fairness (PDF)	0.310	0.052	5.98	0.000
Current level of fatalities * Effectiveness (FAT * EFF)	0.044	0.057	0.76	0.446
Cost * income (COST * income)	-0.052	0.016	-3.14	0.002

0-LL = -457.0227

Final-LL = -423.5754

McFadden's ρ^2 = 0.0732

n = 52

Scaling: COST = millions of €, FAT = levels (1,2,3)

One first indicator of the quality of the model is the McFadden's ρ^2, which describes the percentage of the initial uncertainty that is explained by the model. It ranges from 0 to 1, where for zero the model is as good as "throwing a dice' and 1 is the perfect deterministic model. The estimated MNL model has a McFadden's ρ^2 equal to 0.0732, which means that the estimated model explains 7.32% of the initial uncertainty. However, this value seems relatively low, since according to McFadden values of this ρ^2 that are between 0.2 and 0.4 represent an excellent model fit (McFadden, 1977).

Therefore, this relatively bad model fit is a good indicator for the importance to take the heterogeneity of the sample into account and thus estimate a panel effect ML model, as already has been mentioned that will take place in the following section. However, it is still interesting to investigate the results of this model, since they give a good first impression of the impact of the attributes to the choice of citizens regarding road safety policy options that have fairness consideration.

First of all, the negative estimated value of the constant shows that there is a preference over the status-quo, because there were some policy dimensions that were not included in the experiment and have an influence for accepting a policy. These dimensions include also the important attributes that were identified in Preliminary Research chapter (*Chapter 4*) but were omitted from the design of the experiment as explained in the Experimental Design chapter (*Chapter 5*). In order for a policy to have higher chances to be chosen compared to the "none of the above" option, the total utility contribution of all the attributes that are included in the experiment need to be larger than the value of the constant.

By looking at Table 16 below, which presents the utility contribution ranges for each attribute, it can be seen that the attribute with the biggest influence has been proved to be the effectiveness of the road safety policy. For the utility contributions of effectiveness, the interaction with the current level of fatalities has been taken into account as well. As expected, from the model estimation it is observed that the more the current number of fatalities the more important the effectiveness of the policy is. The estimated beta for the interaction is not significant compared to the rest of the attributes in the table (Table 15), but if the fact that this beta represents the impact of increasing the current number of fatalities by 300 persons, then it can be concluded that it is still quite influential. For example, if the Effectiveness of a road safety policy is 5 and the current number of fatalities is either 400 or 1000 then the contribution to the utility for each of the cases is equal to $(0.32 + 0.044 * 1) * 5 = 1.82$ and $(0.32 + 0.044 * 3) * 5 = 2.26$.

Table 16 – Utility contribution range per attribute

Attribute	Utility contribution		Utility contribution range
	Lowest	Highest	
COST*	-1.84	2.32	4.16
EFF**	1.82	6.78	4.96
TT	-0.17	-0.51	0.34
PDF	0.61	1.55	1.24

* including interaction effects of income

** including interaction effects of current level of fatalities

The least influential attribute based on the utility contribution ranges turns out to be the size of the non-monetary negative externalities (expressed in travel time increase). In addition, from Table 15 it can be seen that this attribute is to a wide extent statistically insignificant. This is a combination of both the low beta and the big standard error. A bigger sample or a different attribute level selection would probably result in a smaller standard error, and for that reason it has been chosen to keep the attribute in the model estimation, since it is one of the main attributes. As regards the Perceived Distributional Fairness it is clear from Table 16 and the utility contribution ranges, that it does actually has a significant influence on the choice of respondents, but to a lower extent than the Effectiveness and Cost of the policy.

Finally, for the estimation of the cost parameter an interesting observation can be made. That is that the cost parameter has turn out to be positive. However, since the interaction with income is taken into account, it needs to be considered together with the main effect of cost. The From the combined impact it can be seen that after the 5th income group, which ranges from an annual gross household income of 50,000 to 60,000 €, the utility contribution turns out to be negative. Therefore, income groups above 5th have a preference for cheaper policies, while the other groups prefer more expensive.

One possible explanation to this observation could be that people when choosing for an option had in their minds the current way that costs are allocated when a tax is imposed, which most often is the progressive, which means that higher incomes contribute a higher percentage of their total income. Another possible explanation could be that the preferences of people regarding the cost of a policy from the citizen perspective does not follow the same principle as in the consumer perspective, which is that the higher the cost the lower the utility contribution. Based on the second explanation, it can be assumed that from the citizen perspective that this study follows, when governments spend more money on road safety it is generally perceived positively by the lower income groups regardless of the characteristics of the policies that are adopted, while for the higher incomes this perception is negative.

6.3.2. Panel Effect Mixed Logit Model

One of the disadvantages of a simple MNL model is that it considers each observation as independent, which means that it does not take into account that the same individual makes more than one choice in the experiment, thus assumes that their consecutive choices are uncorrelated. Therefore, a panel effect mixed logit (ML) model will be estimated in order to take into account the heterogeneity in the preferences of individuals in the sample. The observed utility function for the ML model is, as can be seen below, the same as in the MNL model. The only change is that for some of the attributes a random parameter will be estimated, which means that the beta will be accompanied by a sigma, which show the variation in the importance of the attribute for the individuals in the sample.

$$Vi = ASC + (\beta_{COST} + \beta_{COST}^{income} * income) * COSTi + (\beta_{EFF} + \beta_{EFF}^{FAT} * FAT) * EFFi + \beta_{TT} * TTi + \beta_{PDF} * PDFi$$

Where $EFF \sim N(EFF, \sigma_{EFF})$, $COST \sim N(COST, \sigma_{COST})$, and $PDF \sim N(PDF, \sigma_{PDF})$

The estimation process of a Mixed Logit model is a repetitive procedure, which starts with an initial small number of Halton draws. If the estimated random parameters are not within twice their standard error values then the Halton draws number is doubled and the process is repeated. In this study the initial number of Halton draws has been chosen to be 250. The attributes that have been chosen to be included as random parameters in this model (as can be seen from the formula above) are Cost, Effectiveness and Perceived Distributional Fairness, since for Negative Externalities the estimated sigma was always close to zero, therefore it was better to exclude it from the model estimation. The estimated parameters of the ML model are presented in Table 17.

Table 17 – Parameter estimation for panel effect Mixed Logit model

Parameter	Estimation	Std Error	t-value	p-value
Constant (ASC)	-1.352	0.511	-2.65	0.008
Cost (COST)	0.325	0.255	1.28	0.201
Effectiveness (EFF)	0.346	0.189	1.83	0.067
Negative Externalities (TT)	-0.076	0.101	-0.75	0.451
Perceived Distributional Fairness (PDF)	0.404	0.071	5.71	0.000
Current level of fatalities * Effectiveness (FAT * EFF)	0.098	0.070	1.41	0.158
Cost * income (COST * income)	-0.082	0.047	-1.74	0.082
SigmaCOST	0.703	0.132	5.33	0.000
SigmaEFF	0.335	0.139	2.40	0.016
SigmaPDF	0.220	0.085	2.58	0.010
0-LL = -457.0227				
Final-LL = -384.8129				
McFadden's ρ^2 = 0.1580				
n = 52				

Scaling: COST = millions of €, FAT = levels (1,2,3)

When the heterogeneity in the preferences of the sample is taken into account the main observation that can be made is that the model fit is improved significantly. For this model the McFadden's ρ^2 is equal to 0.1580. Even though this value is still lower than the 0.2 that represents an excellent model fit it is a significant improvement compared to the 0.0732 of the MNL model.

Another important observation is that even if the values of the estimated betas change, their impact is similar to the MNL model. First of all, the estimated constant is still negative, but slightly smaller than in the MNL. This is probably due to the fact that some of the impacts of the personal characteristics of the participants that were initially included in the constant has been explained away from the random parameter estimations. This effect also applies to the random parameter. However, higher or lower betas do not mean that the parameters are actually more or less important compared to the simple MNL model. As can be seen from the table below (Table 18), the relative importance of each attribute remains the same as with the MNL model, where Effectiveness has been proved to be the most influential attribute. As regards the non-monetary negative externalities, they are relatively more statistically significant than in the MNL model, but as can be seen in Table 17 still not statistically significant enough (p-value is 0.451).

Table 18 – Utility contribution range per attribute

Attribute	Utility contribution		Utility contribution range
	Lowest	Highest	
COST*	-4.13	2.43	6.56
EFF**	2.22	9.6	7.38
TT	-0.38	-1.14	0.76
PDF	0.40	2.02	1.62

* including interaction effects of income

** including interaction effects of current level of fatalities

Furthermore, both from the MNL and the ML the same conclusions can be drawn about the impact of each attribute. For example, even when it comes to the impact of the cost and its interaction with the income of the respondent the same observation can be made. When panel effects are taken into account the cost still has a positive impact to the income groups that have a gross annual household income below 50,000 €, and a negative impact to those above this amount.

Finally, as regards the estimated sigmas that show the level of heterogeneity of the importance of each attribute, the sigma of cost is the biggest from the three, which means that it has the biggest variation in the preferences of respondents. The other two parameters have a smaller sigma, with Perceived Distributional Fairness having the smaller one. Thus, it can be assumed that, compared to the other parameters, there is not so much variation in the preference of respondents regarding the importance of fairness.

6.3.3. Panel Effect Mixed Logit with Interaction Effects Model

From the two models that have been estimated above, the one with the better model fit is going to be re-estimated, but this time including the interaction effects of Perceived Distributional Fairness with the other attributes. As already mentioned, the ML model has a higher McFadden’s ρ^2, but to see which models has a better fit it is not sufficient to only compared their McFadden’s ρ^2. To compare models that are nested (one model contains all the attributes of the other model), it is necessary to perform the Likelihood Ratio test in order to examine whether the second model fits better due to coincidence or not. This requires testing whether the Likelihood Ratio Statistic (LRS), which is calculated with the following equation, is bigger than the χ^2 probability value for the difference in the degrees of freedom (number of additional estimated parameters) of the two nested models.

$$LRS = 2 * (LLB - LLA)$$

For the aforementioned MNL and ML models, the LRS is equal to 2* (-384.8129 – (-423.5754)) = 77.525, and thus larger than 16.266 which is the critical value for degrees of freedom equal to 3 and a confidence level of 0.001. Therefore, the second model has a better model fit than the first model. For that reason, another ML model is going to be estimated taking into account, this time, the interaction effects of Perceived Distributional Fairness with the other attributes. The observed utility function for the ML model with interaction effects of Perceived Distributional Fairness is as follows and the results from the model estimation are presented in Table 19.

$$Vi = (\beta_{COST} + \beta_{COST}^{income} * \ income + \beta_{COST}^{PDF} * PDFi) \ * COSTi + (\beta_{EFF} + \ \beta_{EFF}^{FAT} * FAT) \\ * EFFi + (\beta_{TT} + \beta_{TT}^{PDF} * PDFi) \ * TTi \ + \ \beta_{PDF} * PDFi$$

Where $EFF \sim N(EFF, \sigma_{EFF})$, $COST \sim N(COST, \sigma_{COST})$, $PDF \sim N(PDF, \sigma_{PDF})$

Table 19 – Parameter estimation for the panel effect Mixed Logit model with interaction effects

Parameter	Estimation	Std Error	t-value	p-value
Constant (ASC)	-6.281	1.334	-4.71	0.000
Cost (COST)	1.154	0.411	2.80	0.005
Effectiveness (EFF)	0.210	0.292	0.72	0.473
Negative Externalities (TT)	1.205	0.358	3.36	0.001
Perceived Distributional Fairness (PDF)	2.507	0.510	4.91	0.000
Current level of fatalities * Effectiveness (FAT * EFF)	0.122	0.071	1.73	0.084
Cost * income (COST * income)	-0.084	0.048	-1.77	0.077
Cost * Perceived Distributional Fairness (COST * PDF)	-0.414	0.117	-3.54	0.000
Effectiveness * Perceived Distributional Fairness (EFF * PDF)	0.065	0.080	0.81	0.418
Negative Externalities * Perceived Distributional Fairness (TT * PDF)	-0.536	0.131	-4.10	0.000
SigmaCOST	0.730	0.134	5.45	0.000
SigmaEFF	0.331	0.135	2.46	0.014
SigmaPDF	0.244	0.084	2.90	0.004
0-LL = -457.0227				
Final-LL = -375.3024				
McFadden's ρ^2 = 0.1788				
n = 52				

Scaling: COST = millions of €, FAT = levels (1,2,3)

From a quick look at the table above, one can notice that from the three interaction effects of Perceived Distributional Fairness, the one with Effectiveness has been proved to be statistically insignificant. However, excluding the interaction of Perceived Distributional Fairness with Effectiveness does not improve the model fit, and for that reason it has been chosen to keep it in the model in order to show that the interaction between those two attributes is not significant. This happens mainly due to the small estimation for the parameter, which means that any increase or decrease on the level of Distributional Fairness of the policy does not have an influence on the importance of the Effectiveness of the policy. Therefore, it can be concluded that effectiveness is one of the hard constrains when it comes to choosing for a road safety policy.

On the other hand, both the interaction of Perceived Distributional Fairness with Cost and Negative Externalities have been proved to be highly statistically significant. As regards Cost, in order to estimate its impact to the utility of a road safety policy, it is necessary to consider the main effect together both with the interaction of income and that of Perceived Distributional Fairness. Based on the results in Table 19 the utility contribution of cost can be expressed as (1.154 – 0.084 * income – 0.414 * PDF). The same applies also for the Negative Externalities. To observe the impact of negative externalities one should consider also the interaction with Perceived Distributional Fairness. The utility contribution of the Negative Externalities can be expressed as (1.205 – 0.536 * PDF).

Finally, regarding the model fit of this last model, it is observed that it has a slightly better McFadden's ρ^2, which indicates that it probably has a better model fit that the previous ML model. To see whether the last model actually has a better model fit, the Likelihood ratio test will be used again. In this case the LRS is equal to 2 * (-376.0969 – (-384.8129)) = 17.432, which is again larger than 16.266, the critical value for degrees of freedom equal to 3 and a confidence level of 0.001. Therefore, it can be concluded that the last model has the best model fit compared to the other two models.

6.3.4. Willingness to Pay for Fairness

Based on the outcomes of the Discrete Choice models the willingness to exchange a decrease in one aspect of the road safety policies for an increase in another road safety aspect, and vice versa, can be calculated. The negative of the ratio of the betas of two attributes is called the marginal rate of substitution and represents the willingness to exchange between those two attributes. Below the willingness to exchange the different aspects of the road safety policy for an increase in the perception of distributional fairness is calculated.

Firstly, the Willingness to Pay (WTP) for a one-point increase on the Distributional Fairness perception will be calculated, based on the outcomes of the last model, i.e. the panel Mixed Logit with interaction effects, since it was the one with the best model fit. However, since the study follows citizen perspective and not the consumer perspective, it is more accurate to call the aforementioned WTP as willingness to allocate governmental budget (WTA). In Table 20, the WTA_{COST} for an increase in Distributional Fairness per income group is presented. To calculate this WTA_{COST} the following formula has been used.

$$WTA_{COST} = -\frac{\beta_{PDF}}{\beta_{COST}} = -\frac{2.507}{(1.154 - 0.084 * income - 0.414 * PDF)}$$

Table 20 – Willingness to Allocate governmental budget (in million Euro) for distributional fairness improvement

Income level	Initial distributional fairness perception (PDF)			
	1	**2**	**3**	**4**
< 10,000	-3.82	-10.36	14.58	4.28
10,000 – 20,000	-4.38	-15.87	9.79	3.74
20,000 – 30,000	-5.14	-33.88	7.37	3.32
30,000 – 40,000	-6.21	250.70	5.91	2.99
40,000 – 50,000	-7.83	26.67	4.94	2.72
50,000 – 60,000	-10.62	14.08	4.23	2.49
60,000 – 70,000	-16.49	9.57	3.71	2.30
70,000 – 80,000	-36.87	7.25	3.30	2.14
> 80,000	156.69	5.83	2.97	1.99

As can be observed from the table above, from the combination of Perceived Distributional Fairness of 2 and income of 40,000 € to 50,000 € (26.67) and above the WTA_{COST} is positive. This can lead to the assumption that all income groups are only willing to accept a higher cost if they think that it will result in a fair road safety policy, and that the higher income groups are even willing to accept a higher cost if it would ensure just a neutral policy. However, an increase to either income or the perception of fairness results in a decrease to the WTA_{COST}, which means that people are less willing to accept an increase of cost as the Perceived Distributional Fairness increases. One the other hand, for the lower income groups or perception of Distributional Fairness levels the WTA is negative. Therefore, it can be assumed that any increase in the cost cannot be compensated by an increase in the perception of fairness, and any increase would need to be compensated by an improvement in the other aspects of a policy.

As regards the two extreme values (156.69 and 250.70), it needs to be stated that they are caused due to the small beta of cost for this combination of income and initial Perceived Distributional Fairness level. As already mentioned, in general for the lower income groups the impact of the increase of cost is perceived as positive and for the higher income groups as negative. This in combination with those specific Perceived Distributional Fairness levels causes the total impact of cost to get close to becoming irrelevant (-0.016 and -0.010) for those income groups. Therefore, for those two combinations it is considered more accurate to say that the cost becomes close to irrelevant than assume that people are willing to pay 156 and 250 million Euro to increase the fairness perception by one level.

The same approach as discussed above is also followed in order to calculate the willingness of citizens to trade the Non-monetary Negative Externalities for an increase on Distributional Fairness. The ratio of the betas of Perceived Distributional Fairness and Negative Externalities indicates the willingness of people to accept an increase in travel time for an increase in the perception level of fairness (WTA_{TT}). In Table 21, the Willingness to Accept one minute of average travel time increase per day for an increase in the perception of Distributional Fairness (WTA_{TT}) is presented.

$$WTA_{TT} = -\frac{\beta_{PDF}}{\beta_{TT}} = -\frac{2.507}{(1.205 - 0.536 * PDF)}$$

Table 21 – Willingness to accept negative externalities (in minutes of average travel time per day) for distributional fairness improvement

Initial distributional fairness perception (PDF)			
1	**2**	**3**	**4**
-3.07	-15.47	5.10	2.19

As can be observed from the table above, the WTA_{TT} has a positive value (5.10 and 2.19) for policies higher than neutral in terms of perceived distributional fairness. However, for policies that are considered unfair or slightly unfair in the first place the WTA_{TT} has a negative value (-3.07 and -15.47). This can lead to the assumption that people are only willing to trade an increase in travel time if they think that it would result in a fair road safety policy. If not, then any increase in travel time cannot be compensated by an increase in the perception of fairness, since it would still be perceived as unfair or in the best case neutral. Therefore, any increase in travel time needs to be compensated by an improvement in the other aspects of the policy.

Finally, as mentioned in the outcomes of the last model, the impact of Effectiveness is not influenced by any change in the level of Distributional Fairness of the road safety policy. Therefore, the Willingness of respondents to accept a decrease in Effectiveness for an increase of Distributional Fairness is the same for all its levels. Since the interaction of Perceived Distributional Fairness with Effectiveness is statistically insignificant the estimated parameters of the first ML model are going to be used to estimate the Willingness to Accept a reduction in Effectiveness for an increase in Perceived Distributional Fairness (WTA_{EFF}).

$$\mathrm{WTA_{EFF}} = -\frac{\beta_{PDF}}{\beta_{EFF}} = -\frac{0.404}{(0.346 + 0.098 * FAT)}$$

From the formula above it is obvious that the $\mathrm{WTA_{EFF}}$ is influenced from the current level of fatalities. If, for example, the number of road fatalities in the Netherlands for 2018 is used, which is 678, then the $\mathrm{WTA_{EFF}}$ takes a value really close to zero (-0.006). Therefore, it can be concluded that people are not willing to trade a single reduction in the total number of fatalities saved for a more fair road safety policy. In the following table (

Table 22) the $\mathrm{WTA_{EFF}}$ for the three levels of fatalities that have been included in the study is presented.

Table 22 – Willingness to accept a reduction in effectiveness (in terms of fatalities) for distributional fairness improvement

Current level of road fatalities		
400	**700**	**1000**
-0.010	-0.006	-0.004

Finally, it is important to make a clarification as regards the calculations of the willingness to exchange the different aspects for an increase in the perception of distributional fairness. This is that the reason they are calculated is not to be used directly in a CBA, but to show the effects of including the interaction effects of fairness with the other aspects in the last model estimation. One reason to avoid using it directly in a CBA is that this willingness to exchange is not necessarily expressed into monetary terms as required in a CBA, and even if it is, it refers to cost from the citizen perspective, i.e. money paid by the government, and not the consumer one.

Moreover, as mentioned in *Chapter 2*, the use of the WTP in a CBA is often criticized, because it assumes that it is equal for every income group. However, if a different WTP is estimated for each group, as in this study, then using them in a CBA is similar to applying distributional weights for each different income group, which contradicts to the main principal of CBA, which is giving everyone an equal weight, as it is based on the utilitarian theory. Therefore, in this study the willingness to exchange different aspects of the road safety policies is not calculated in order to be used directly in a CBA, as it is usually the case with WTP, but to indicate if and to what extend an increase of the negatives effects or a decrease of the positive effects can be compensated with a more fair road safety policy.

7. Discussion, Conclusions and Recommendations

In this chapter the results of this study will be discussed, together with a reflection to the literature and the contribution of this study (*Section 7.1*). In *Section 7.2* the conclusions based on the results of this study are presented, followed by the limitations of the study in *Section 7.3*. Finally, several recommendations, both scientific and practical, are given in *Section 7.4*.

7.1. Discussion

As this study is the first, to my knowledge, that has approached the road safety research field from the perspective of the distributive justice, and therefore are no previous studies in order to compare the results and check their consistency. However, there are a few reflections that can be done back to the literature, and more specifically to the statements that motivated following specific research approaches and methods, or conducting the study in the first place.

First of all, this study is consistent with the view of Roemer (1998) that the Discrete Choice Approach, even though it is a technique that is mostly used by economists, it can also test the consistency of philosophical theories and provide with a better understanding of the vague nature of some of their aspects. This also applies in the field of road safety policymaking, as it is shown in this study, where a model has been used in order to translate the philosophical views related into the distributional fairness into qualitative aspects of policies.

Another contribution of this study is that it has shown that, as it was initially suggested by Chorus (2015), the Discrete Choice Approach does actually provide insight to moral dilemmas. More specifically, as regards this study, the Discrete Choice Approach contributed into getting a better understanding of the preferences of the citizens on the ethical choices that policymakers need to make regarding the distribution of the effects of road safety policies to different groups of people or regions of their country. Since the way that the different effects of the road safety policies are distributed influences the perception of people about the fairness level of the policy, and consequently affect its public acceptability, this study confirmed the views of the Dutch policymakers mentioned in Mouter (2017) that CBA can sometimes be misleading, as it does not provide any information about the distribution of the effects to the different groups of people or regions.

Finally, as there is no previous study in order to discuss the consistency of the results of this study, those results can be seen as a contribution to the existing literature related this topic. Therefore, it is considered preferable to attempt to summarize and present the results of this study by answering the main Research Question that this study aims to address. By answering each of the sub-questions that were formulated in the *Introduction*, the main research question is going to be answered as well. Therefore the answers for each sub-question are presented separately below, since for each of them a different experimental method has been used.

Which equity theories can be applicable in road safety policies?

As already mentioned in the literature review chapter (*Chapter 2*), there are more than one way to define fairness. In this study fairness is defined as the distributional fairness, which varies in three distinctive dimensions. The first dimension is related to which effects are going to be distributed. The second is related to the nature of the recipients, and their categorization criteria. The third, and last, dimension is the basis on which the distribution should be made in order to be considered as fair. Depending on the perspective from which distributional fairness of a policy is examined, fairness can be considered in more than one way.

As regards the equity theories or types that can be found in literature and can be potentially applied in examining fairness of road safety policies, those are related to the second and third dimension of distributional fairness. For the second dimension, which is related to the way that the recipients of the effects are categorized in different groups, the equity types that have been found in literature and can potentially be used for road safety policies too are:

1. Horizontal equity (inside categories of comparable individuals, groups or regions)
2. Vertical equity (between groups, depending on how advantaged or disadvantaged they can be considered)
3. Spatial equity (between different geographical locations)
4. Social equity (consists of a personal, economic or social perspective for different categories of individuals, groups and regions)

The four types of equity are the ones that have been used in this study too. For the third dimension of distributional fairness, which is how a fair distribution is defined, several theories have been found in literature and are as follows:

1. Equal shares distribution (effects are distributed equally to everyone)
2. Utilitarian theory (maximize the aggregate benefits and give everyone an equal weight)
3. Egalitarian theory (bigger benefits to the more disadvantaged individuals, groups or regions until equality is achieved)
4. Rawls' theory of justice or Rawls' egalitarianism (benefits are distributed only to the most disadvantaged until equality is achieved)
5. Sufficientarianism (focus on the absolute levels of indicators before and after the policy for specific groups that are below a certain threshold)

6. Maximizing the average net benefits with a minimum floor benefit (specific groups of people or regions receive at least a specific minimum amount of the benefits)
7. Maximizing the average net benefits with a benefit range constraint (no difference between different groups of people or regions over a certain amount of benefits is allowed)

Which factors influence citizens' perception of distributional fairness in road safety policies?

The aspects that influence the perception of distributional fairness of road safety policies has been identified from the outcomes of the preliminary research (i.e. focus group and individual interviews). However, not all of those aspects have been included in the experiment that has been conducted in this study. The aspects that are directly related to the perception of distributional fairness and are included in the experiment, are the ones that describe the different types of distributions. Those distributions, whose connection to the equity types can be seen in Figure 17, are the ones also presented below.

Distribution of road safety benefits:

- Spatial distribution
- Distribution to the different road user types (or modal distribution)
- Distribution to the different age groups

Distribution of monetary costs:

- Distribution to the different road user types (or modal distribution)
- Distribution to the different income groups

Distribution of non-monetary negative externalities:

- Distribution to the different road user types (or modal distribution)
- Distribution to the different age groups

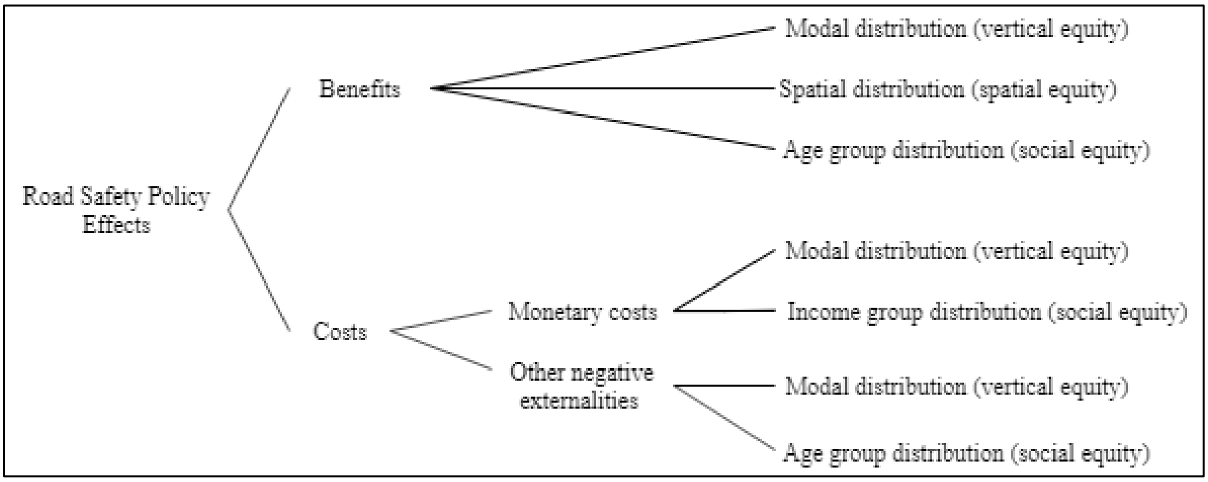


Figure 17 – Important aspects related to the distribution of effects of road safety policies

Finally, the non-distributional related aspects that might affect people's perception of distributional fairness, are related to the general characteristics of the road safety policies and they are the following:

- Type of the road safety policy (i.e. road-related, vehicle-related, enforcement-related and road-user related)
- Scale of the geographical focus area of the road safety policy
- How are the monetary costs paid (paid directly by the road users or by government via taxation)
- Level of participation of different groups of citizens in the design and decision-making process

For those aspects it is not possible to say with certainty whether they actually influence indirectly the perception of distributional fairness by interacting with other factors of the road safety policies because they were not included in this study (or have been fixed to a specific value).

To what extent do these factors influence citizens' perception of distributional fairness in road safety policies?

After conducting the preliminary research experiments to identify the factors that influence the citizens' perception of distributional fairness of road safety policies, the rating experiment was conducted in order to observe the extent to which they influence this perception. Therefore, Linear Regression models were estimated, to understand the impact of the different types of distribution for the identified influential factors-attributes that are shown in Figure 17 to the perception of distributional fairness of a road safety policy. The influence of the different types of distributions of the effects of road safety policies on the perception of Distributional Fairness is discussed below.

Road Safety Benefits

Spatial Distribution. None of the different types of spatial distribution has a negative effect on the perception of distributional fairness compared to the equal distribution of the road safety benefits to the different regions. Focusing on the different regions based on their current level of fatalities and allocating the road safety benefits proportionally to those regions is considered the most fair type of spatial distribution of road safety benefits.

Distribution to modes. Aiming on increasing safety only for the car users has been proved to have a negative impact on the perception of distributional fairness. On the other hand, focusing on the vulnerable road users or the public transport users has no added-value in the fairness perception compared to focusing on all the road users equally. Hence, those distributions can be considered to be perceived as more or less equally fair.

Distribution to age groups. As regards the distribution of the road safety benefits to the different age groups, focusing on saving specific age groups is perceived to be relatively unfair compared to focusing on all road users regardless of their age.

Monetary Costs

Distribution to modes. Allocating the monetary costs to implement a road safety policy to all citizens is considered to be more fair compared to allocating them only to the car users, as a tax imposed to car owners. Especially for car owners, this negative perception regarding fairness is more intense compared to those that do not own a car.

Distribution to income groups. As regards the allocation of the monetary costs to the different income groups, the most fair type of distribution has been observed to be the proportional distribution where the road users, on which the tax will be imposed based on the distribution above, pay the same percentage of their income. The second most fair distribution is the progressive distribution, where road users pay a higher percentage of their income as their income increases. Finally, what need to be also considered is that as income increases these types of distributions have a lower impact to fairness perception. However, the equal distribution is never considered more fair, even for the higher income groups.

Non-monetary Externalities

Distribution to modes. Allocating the non-monetary externalities (in terms of average travel time increase per day) to all modes of transport or only to car users is perceived as more fair than allocating them only to the vulnerable road users or public transport users. More specifically, when the vulnerable road users and the public transport users receive the increase in the average travel time there is a negative impact on the perception of fairness. However, if someone uses the car as a mode of transport to commute then allocating the negative externalities only to car users is perceived as the most unfair type of distribution. For this group of respondents, the equal distribution is perceived as the most fair distribution of all.

Distribution to age groups. As with the distribution of road safety benefits to the different age groups, allocating the non-monetary negative externalities in terms of reducing the mobility of either the young age groups or the elderly is considered to be unfair compared to allocating them equally to all age groups.

To what extent does the perceived distributional fairness influence the preference of citizens over different road safety policy options that have fairness implications compared to other aspects of those policy options?

The distributional fairness perception has been proved to be an influential aspect for the road safety policy choice of people. However, it has not been proved as significant as the monetary cost and the reduction in the total number of fatalities. Moreover, perceived distributional fairness has also an indirect impact to their preferences for different policy options, since despite its main effect, it also has an interaction with the other aspects of the policy, i.e. effectiveness, cost and negative externalities.

More specifically, perceived distributional fairness influences the impact of the negative effects of road safety policies to the choice of people, but not the positive ones. In other words, people are willing to trade an increase in the negative effects, such as the cost or the non-monetary externalities, for an increase of the distributional fairness. However, they are not willing to trade the positive effects of a policy, which in this case are the safety benefits.

7.2. Conclusions

As the literature suggests and as the results of this study showed, low public acceptance can be a show-stopper for road safety policies. Looking only at the aggregate effects of a road safety policy can be often misleading. The way that the effects of road safety policies are distributed among different groups of people can have a significant influence on the public acceptance of road safety policies, since they influence the perception of distributional fairness of the policy. Moreover, several characteristics of the people (such as their income, whether they own a car or not and their most frequently used mode of transport) have shown an influence on the way that they perceive what is fair or not. Therefore, it also important to consider the characteristics of the population that is going to be affected by a specific road safety policy measure.

One of the most important findings of this study is that people are actually more willing to accept a policy that is more expensive or results in larger negative effects if they think that the effects of this policy are distributed in a more fair manner. However, they are not willing to trade all aspects of a policy for an increase on distributional fairness. The effectiveness of a road safety policy, i.e. the total number of road fatalities saved, has been proved to be one of the hard constrains for road safety policies, since people are not willing to trade a single reduction in the number of fatalities saved for a more fair policy, if all the other characteristics of the road safety policy alternatives are the same.

To conclude, if policymakers want to be able to identify the road safety policy options that have the highest potential public acceptability chances, they should try to incorporate those considerations into the design and decision-making process more adequately, rather than just form an opinion solely on the results of the Cost Benefit Analysis.

7.3. Limitations of this Study

Despite its contribution, as it happens with every research, this study has its limitations too. Those limitations are going to be presented in this section, and their influence on the quality of this study is going to be discussed.

Preliminary Research Limitations

As regards the preliminary research, that has been conducted in order to gather the important information to design the main experiment of these studies, several limitations have been identified. Firstly, for the focus groups discussion the main limitation is that it has been conducted including only students of the Delft University of Technology. Even though this ensured having a successful session, where participants feel confident to participate, it resulted into leaving out other sociodemographic groups that could possibly provide different perspective or insights, resulting in identifying aspects that might have been omitted from this study.

The individual interviews, on the other hand, did not prove to be as efficient as the focus group session, even though they provided some interesting findings. The lack of other participants or a familiarity with the topic by the interviewees, required a lot of guidance or even resulted in hesitation to answer the questions. Thus, even though they have provided useful information for the study and ensured that people of other sociodemographic groups are included, it is believed that individual focus groups session with each of the different sociodemographic groups should take place.

Experimental Design Limitations

Apart from the preliminary research, the main experiment of this study was substitute to several limitations. The first one is related to the aspects that indirectly influence the distributional fairness perception of road safety policies and have been either omitted from the experiment or they have been fixed to a specific value. However, it would be interesting to see how the perception would be influenced by these aspects, even though they will result in a larger experimental design.

Another limitation regarding the experimental design is the choice to remove the types of distribution that seemed unrealistic for the road safety policies of the first experiment. This probably resulted in a worse model fit, due to the limited information regarding the lower part of the scale of the distributional fairness perception. For the road safety policy choice models, and more specifically the simple Multinomial Logit and the first Mixed Logit model, the effect of negative externalities has been proved to be statistically insignificant. Therefore, this attribute doesn't influence people's choice. A reason for that could potentially be that the different attribute level values that have been chosen for this experiment were too close between them in order to offer enough trade-off to the respondents.

Finally, one major limitation of this study is related to the fact that respondents have been asked to evaluate the road safety policy alternatives as individual policies, and not as part of a wider road safety policy program. However, in reality this is not accurate, since policies are always part of a wider program, which consists of road safety measures of different types. To reduce the influence of this limitation the "none of the above" option has been added as an alternative, where respondents had to recommend to the government whether to add the chosen road safety policy option to the existing road safety policy program.

However, this program has not been defined, therefore individuals might not have all the necessary information to answer this question. For example, if the national road safety policy program has a specific regulation on speeding, adding a new regulation on speeding will mean that the initial one is removed, while adding an infrastructure related measure that might interact positively with the initial speeding regulation, will both keep the initial regulation in the program and increase the chance that people will want it to be added.

Research Sample Limitations

The main research approach has been conducted based on a relatively small sample of respondents. In total out of the 130 that started the survey only 64 completed the whole survey, which equals to only 49%. The following graph (Figure 18) shows the number of respondents that answered each of the questions, which gives an indication on at which point they quit the survey.

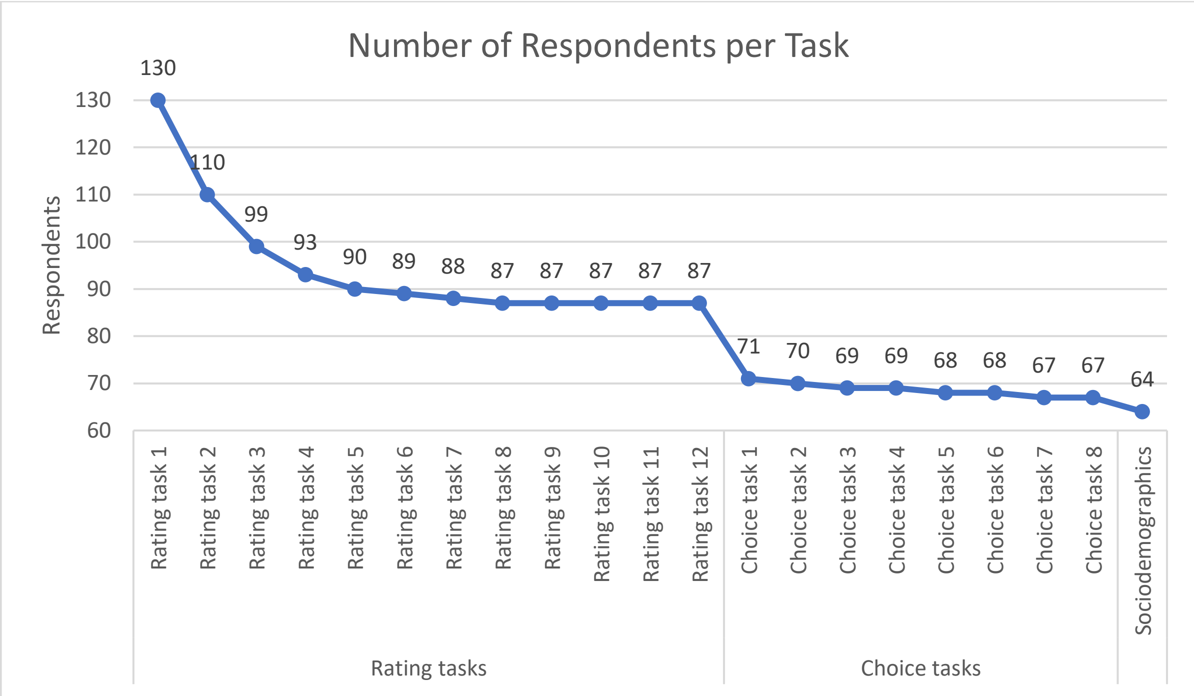


Figure 18 – Number of respondents that answered each task

As can be seen, most respondents quitted the survey on the first three rating tasks, which can lead to several assumptions regarding the survey questionnaire. First of all, since they left the survey in an early stage, it can be easily understood that it wasn't due to the large size of the questionnaire. One potential issue could be the way that the first experiment had been formulated, since even though there was an effort to provide the least information necessary, there was still probably an overdose of information at each of the rating tasks. A more user-friendly questionnaire, with either less information per task (if possible) or presenting the information in a more interactive and interesting way would probably ensure a bigger sample.

The small sample combined with the big variation in the answers and the omission of the unrealistic attribute levels that would result in unfair policies, as mentioned before, resulted in the relatively low model fit of the Linear Regression model. Moreover, the relatively small sample reduces the quality of the choice models as well, even though they can be considered relatively good. This is because the 64 respondents have been allocated to a different experimental block, thus for each profile there were only 18, 19 or 27 respondents depending on the block they belonged to.

Overestimation of the Importance of Fairness

Finally, one last aspect to be considered, and is probably related to all the aforementioned limitations of the main experimental method, is the possibility that mostly people that consider fairness to be important in the first place took the time to consider starting and actually completing the whole survey. Moreover, from the way that the experiment has been set, the respondents were aware at the beginning that this study focuses on fairness consideration of road safety policies. Therefore, it should be kept in mind that participants could be biased in their answers, and the importance of fairness might have been overestimated in this study. A study with a bigger sample and similar results could make the outcomes of this study much more concrete.

7.4. Recommendations

Finally, several recommendations are going to be provided based on the outcomes and the conclusions of this study, as well as its limitations. Firstly, recommendations regarding potential future research studies on the topic are discussed in *Section 7.4.1*. Secondly, since the aim of this study is to help policymakers to choose the road safety policies that have higher public acceptability chances, some policy recommendations are presented in *Section 7.4.2*.

7.4.1. Recommendations for Future Research

Based on the aforementioned conclusions and limitations of the previous chapters, several scientific recommendations are presented regarding potential future research related to the topic that this specific study explores. These recommendations are as follows.

Preliminary Research Improvements

In the previous section, it has been mentioned that the focus groups discussion has been proved to be more efficient than the individual interviews, and that it would be better to conduct more focus group sessions. It is preferable to conduct focus groups with homogeneous participants since the objective is to stimulate the interaction between the participants, and thus understand the needs and preferences of each of the different types of stakeholders.

Therefore, conducting an individual focus group discussion for each of the relevant stakeholder groups, such as citizens, public authorities, policymakers, road safety experts etc, is recommended. From these focus groups different aspects might arise from the ones that have been already identified from the focus group discussion of this study. For example, for some of those stakeholder groups, the direct environmental effects of a road safety policy might be considered significant in the choice of a policy option. This study only covered this aspect indirectly by including the non-monetary externalities in terms of added travel time, which theoretically result in higher air pollutant emissions. However, it would be interesting to include this aspect more adequately, with quantitative measurements directly related to the environmental aspects of a policy, such as CO_2 emissions or km of lost green space etc.

Replication of the Study with a Bigger Sample

The small number of respondents in the main experiment resulted in less confidence regarding the outcomes of the models. Therefore, it is considered necessary to, at least, replicate the experiment of this study (if not improve it) with a bigger sample than the current one. If similar results are obtained, then the outcomes of this study can be considered much more reliable.

Different Types of Models

In this study the Linear Regression model has been used, instead of the Ordered Logit for the first experiment. The reason for that was that the second model would result in a bigger experimental design for the second experiment if Ordered Logit is used, since the equal intervals between the different levels of fairness does not apply in that case. Therefore, all five levels of fairness would be required to be included in the choice experiment. However, the Ordered Logit model would be able to predict more adequately the real preference of people, since it would not assume a linear relationship between the different scores. This would have reduced the problem with the lower part of the scale, since in the Ordered Logit models each level is represented by a threshold value, and not the actual levels.

As regards the Discrete Choice models for the Road Safety Policy Choice experiment in this study only the Random Utility Maximization (RUM) theory has been used as a selection criterion. However, it is recommended to try in a future study to apply the Random Regret Minimization (RRM) theory or even estimate a combined RUM-RRM model. Regret-based models, according to Chorus (2012), assume that when people have to choose an option from a choice set, they want to minimize the regret and not maximize the utility. Therefore, when choosing, people compare every alternative with each of the others in terms of each attribute. What they aim is to avoid that the chosen alternative is outperformed by one or more of the non-chosen alternatives on one or more attributes, which causes the regret. Regret has been proved to be an important determinant of choice behaviour of people.

Finally, two of the outcomes of this study are that, first, effectiveness (in terms of reduction in the number of fatalities) is influenced by the reference level, which is the current level of fatalities. Secondly, people often rejected both alternatives and chose to keep the status-quo as it is. The advantage of the RRM model, according to Chorus (2012), is that it already assumes that the evaluation of an alternative depends on its performance compared to a reference point, and that losses compared to that reference point have a larger impact than gains of the same magnitude. Moreover, with such a model it is possible to observe the existence of compromise-effects in the behaviour of people (Chorus, 2012). For more details on the RRM models see Chorus (2012).

Different Experimental Techniques

Finally, one last scientific recommendation regarding potential future research is to consider applying a different and more interactive method to explore choice behaviour of people. One such approach, that have been previously used in transportation research and can potentially be applied in road safety policymaking, is the Participatory Value Evaluation (PVE). According to Mouter, Koster, & Dekker (2019), who conceived PVE as a potential alternative of CBA, *"in a PVE, individuals are asked to choose the best portfolio of projects with corresponding impacts for society and themselves subject to governmental and private budget constraints"*. This approach can be also applied on road safety policies, where instead of a portfolio of projects, citizens are asked to choose a road safety policy program, from a pool of road safety policy alternatives.

Another method that can be potentially applied is that of gamification. Gamification is a research method where the experiment is conducted in the form of a game (either board or video game). In the field of transportation, this method has been gaining a lot of attention mostly in the field of freight transport, in order to understand the preferences and the behaviour of the different stakeholders that consist the supply chain. Some examples of studies that have applied such an approach in freight transport are those of Kourounioti, Kurapati, Lukosch, & Verbraeck (2018), Kurapati & Kourounioti (2018) and Karampelas (2018). One way that this method can be potentially applied in the field of road safety research is, for example, by having the players-participants design a road safety policy program, consisting of individual road safety policy measures of specific characteristics, for a hypothetical country based on a specific game objective, a described problematic situation that needs to be addressed, resources limits, environmental goals and even EU objectives and regulations, among others.

These two different methods can potentially resolve all of the aforementioned limitations regarding the main experimental method of this study, such as the small sample due to the user-unfriendly nature of survey questionnaires, the exclusion of several policy specific characteristics, or even the overdose of information that resulted splitting the Stated Preference experiment into two parts. To make it clear, as regards the overdose of information, these techniques are not going to result in presenting less information. Instead these two methods might result in a bigger size of information presented to the participants, but the interactive way that the information is presented could reduce the feeling of the respondents that they are exposed to a huge load of information.

7.4.2. Policy Recommendations

It is often said that "change requires political actions". To help policymakers in this aspect and in order to assist them to make their policy interventions more efficient, two recommendations are presented in this section, based on the outcomes of this study.

Promote social dialogue

The first suggestion is to promote the importance of social dialogue among all the different stakeholders related to road safety policymaking, such as the road safety researchers and experts, local authorities, citizens, or associations (like the motorcyclist associations, trade associations etc.). Taking into account the preferences of people in the design and decision-making process, will have a positive impact to the public acceptability of those road safety policies. This can be done either in a form of a discussion between the aforementioned types of stakeholders or, as it has been done in this study, via focus group sessions and individual interviews.

Incorporate fairness considerations in the decision-making process

This study has shown that it is not only sufficient to consider the aggregate effects or a road safety policy, but it is also necessary to take into account the way that those effects are distributed. Therefore, one suggestion to policymakers is to try to incorporate the fairness consideration of road safety policies into the decision-making process. This can be done in two ways. The first way is to include fairness considerations in the appraisal by integrating it into the existing CBA framework by using distributional weights or equity values for the costs and benefits of different groups.

However, there are two disadvantages with using distributional weights and equity values. The first one is that they still provide no information to the policymakers about how specific impacts of the alternatives are distributed among the population groups or regions. Moreover, applying weights comes in contradiction to the main principal of CBA, which is giving everyone an equal weight, since it is based on the utilitarian theory.

Therefore, the second way, which is to accompany CBA with a separate equity analysis is considered a more suitable solution. More specifically the equity analysis should focus on the distribution of the effects of the considered road safety policy alternatives that are included in their aggregate levels in the CBA, to the different groups of people or regions. This way the integrity of CBA is maintained and the added value of the information regarding distributional fairness is included effectively in the process.

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Appendix A – Scientific Journal Paper

Distributional Fairness in Road Safety Policies: A Discrete Choice Approach to Explore Citizens' Preferences on the Distribution of the Effects of Road Safety Policies

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Abstract

This study aims to explore the preferences of citizens regarding fairness considerations related to the distribution of the effects of road safety policies in order to provide with policy recommendations that will help to promote more fair road safety policies. To achieve this aim the Discrete Choice Approach is going to be followed, using stated preference data. This requires a Stated Preference experiment has been conducted, which consisted of two distinct parts. The first part is related to the citizen's perception of fairness of road safety policies and how the attributes that influence it contribute to this perception, while the second one is related with the importance of this perceived fairness in the preference of citizens over specific road safety policy alternatives. For those two experiments several Linear Regression and Discrete Choice models have been estimated. This study has also shown that the Discrete Choice Approach can actually give some insight to moral dilemmas as literature suggests. It also showed that low public acceptance can be a show-stopper for road safety policies, thus looking only at the aggregate effects of a road safety policy can be often misleading. The way that the effects of road safety policies are distributed among different groups of people can have a significant influence on the public acceptance of road safety policies.

1. Introduction

To define a policy or policy program as "good", it does not only have to be effective, but also efficient and fair (van Wee, 2011). Generally, policies are often rejected, even though they are cost-efficient, due to low public acceptability which results from social aspects of policies, such as how fair people think that a specific policy is (Noordegraaf et al., 2014; van Wee, 2010).

One of the most widely used evaluation tools to assess road safety policies is the Cost-Benefit Analysis (CBA) (Bristow & Nellthorp, 2000; van Wee, Hagenzieker, & Wijnen, 2014; Elvik, 2001). However, in general CBA as a tool focuses mainly on the economic efficiency of a project or policy, which is the net contribution of it to the national income, rather than on equity issues related to the project or policy (Martens, 2011).

Moreover, according to Mouter (2017), several Dutch politicians argue that CBA can be misleading in several cases, since despite providing with the possibility to include social impacts, it does not provide any information about their distribution across population groups or different regions. Another disadvantage of the CBA is that it only evaluates the changes resulting from a policy and not the absolute values after implementing it. If someone is interested in the absolute values of an indicator (such as number fatalities) for different groups of people after implementing a policy, then CBA is not an appropriate assessment tool.

2. Research scope

This study aims to explore the preferences of citizens regarding fairness considerations related to the distribution of the effects of road safety policies in order to provide with policy recommendations that will help to promote more fair road safety policies. This means that the scope of the study is limited to examine only fairness from the aspect of distributional fairness. Other ethical perspectives such as criminalization, paternalism, privacy, responsibility or procedural justice were beyond the scope of this study.

Distributional fairness describes how a society should allocate its resources or goods to individuals or groups with competing needs or claims (Deutsch, 1975). Distributional fairness varies in three distinctive dimensions (Stanford Encyclopedia of Philosophy, 2017). The first dimension is related to which effects are going to be distributed. This dimension is solely related to the nature of the policy, and in the case of road safety policies those effects could be, for example, the road safety benefits, or the costs to implement a policy.

The second dimension is related to the nature of the recipients, and their categorization criteria. This dimension is closely related to the perspective from which the policy is examined. Depending on the perspective from which distributional fairness of a policy is examined, fairness (or "equity" as it also mentioned often in literature) can be considered in more than one way. Some of the equity types, that can be often found in literature and fairness related studies in the transport field of research, are (Khisty, 2007; Thomopoulos et al., 2009):

5) **Horizontal equity**, where fairness in the distribution of the effects (both costs and benefits) of a policy is examined inside categories of comparable individuals, groups or regions, to observe whether the members inside those categories are treated in a fair manner.
6) **Vertical equity**, where fairness in the distribution of effects of a policy is examined between groups, depending on how advantaged or disadvantaged they can be considered, regarding the aims and objectives of the considered policy.
7) **Spatial equity**, which refers to the geographical location of individuals, groups, regions that receive the effects of a policy and whether they are distributed in a fair way among these locations.
8) **Social equity** is associated with the distribution of effects of policies, but examined in a personal, economic or social perspective for different categories of individuals, groups and regions.

The third and final dimension is the basis on which the distribution should be made in order to be considered as fair. Apart from the different equity types that can be used to examine fairness issues, there is also a variety of equity principles and theories of justice in literature that can be used to describe how the distribution should be made in order to achieve fairness. Some of those principles, for example, that have practical applicability in transport project and policy appraisal are (Khisty, 2007; Pereira et al., 2017; Thomopoulos et al., 2009; van Wee & Geurs, 2011):

8) **Equal shares distribution**, meaning that a policy is fair when the effects are distributed equally to everyone.
9) **Utilitarian theory**, that aims in maximizing the net benefits of all people and gives an equal weight to everyone.
10) **Egalitarian theory**, where fairness is achieved when everyone is considered equal. Thus, policies that reduce current inequalities and give bigger benefits to the lower socioeconomic groups are following the egalitarian theory.
11) **Rawls' theory of justice** or **Rawls' egalitarianism** argues that a policy should not aim to maximize the total benefits, but only to provide the least advantaged members of society with the greatest benefits. The benefits of the other groups play no role in this theory.
12) **Sufficientarianism**, which states that policies should give priority on groups of people that are below a certain minimum threshold. This theory focuses on the absolute levels of important indicators before and after implementing the policy and not on the differences in the benefits provided between different groups by the policy.
13) Distribution based on **maximizing** the average net benefits with a **minimum floor benefit** for everyone. In this case fair is when there is an attempt to maximize the benefits with the constraint that specific groups of people receive a certain minimum amount of the benefits.
14) Distribution based on **maximizing** the average net benefits with a **benefit range constraint.** In this case fair is when there is an attempt to maximize the benefits, without allowing differences over a certain amount in the benefits of different groups of people.

3. Methodological Approach

To achieve the aim of this study the Discrete Choice Approach is going to be followed, using stated preference data. The Discrete Choice Approach is a widely used technique by economists and as Roemer (1998) argues *"the economist's way of thinking can check the consistency of a philosophical theory or provide a concrete formulation (a model) to make more precise some of its still vague assertions. It can often translate a philosophical view about distributive justice into a concrete social policy"*. Moreover, Chorus (2015) adds that applying the Discrete Choice Approach in the domain of moral choices can offer a more empirically rooted understanding of how individuals make those moral trade-offs, which will be beneficial for those attempts.

In this study a Stated Preference experiment has been conducted where participants specified their choices over different hypothetical road safety policy alternatives that include fairness considerations, among other policy characteristics. However, in order to create those hypothetical scenarios, fairness needs to be defined and measured first. This was done again with the Stated Preference method, where people evaluated road safety policies on their fairness based on some characteristics that were presented to them.

This means that for this study, the construction of two distinct Stated Preference Experiments is required, similarly to Molin, Blangé, Cats and Chorus (2017) who followed a HII and integrated choice experiment combination methodology in the field of air travel safety. These two Stated Preference Experiments are linked together by the perception of fairness, as can be seen in Figure 1 which shows a graphical representation of the proposed methodology. The first experiment is related to the citizen's perception of fairness of road safety policies and how the attributes that influence it contribute to this perception, while the second one is related with the importance of this perceived fairness in the preference of citizens over specific road safety policy alternatives.

In the first experiment, respondents will be asked to evaluate different road safety policy options. To evaluate those options, they will have to score them on a rating scale based on how fair they think they are in their opinion. Those road safety policy options will be described in terms of attributes that are influential on people's perception of fairness, based on the preliminary experiments. From this experiment the extent to which each attribute determines the perception of fairness of people will be estimated. The advantage of this first experiment is that it resolves the difficulty of defining and measuring fairness, in order to include it consequently into the second Stated Preference experiment.

In the second Stated Preference experiment, the perception of fairness will be included as an attribute of the experiment, together with other observable policy attributes that are considered important when deciding over different road safety policies. Those observable policy attributes (e.g. cost, reduction in fatalities etc.) will be also obtained from the preliminary experiments and from the relevant literature. The values of perceived fairness in this experiment will be determined by a statistical design.

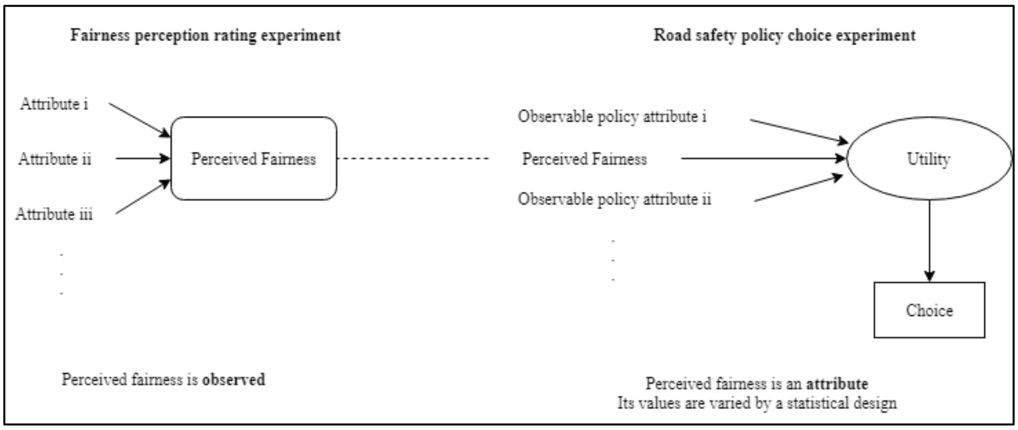

Figure 1 – Graphical representation of the simultaneous Stated Preference experiments (adapted from (Molin et al., 2017))

4. Preliminary Research

Prior to the Stated Preference experiment, described above, it is important to conduct a preliminary research, in order to obtain all the necessary attributes, that will be used in the two parts of the stated preference experiment. This preliminary method consists also of two parts. The first part consists of a focus group discussion, while the second of individual exploratory interviews.

The focus group is a qualitative research technique from the category of group interviews. The main characteristic is that it uses the interaction between the participants during the discussion to gather the data. During a focus group discussion, it is not necessary that the participants reach an agreement, but rather exchange information, experiences and their points of view on the topic. This method is preferred when it is important to examine not only what people think, but also the "how" and "why" (Kitzinger, 1995).

On the other hand, the individual exploratory research interviews have been conducted among non-student or academic people of a different age group. The reason that this method has been chosen is that it would be difficult and time consuming to organize another focus group in the time span of this study.

Table 1 – Characteristics of Focus Group and Interviews participants

No.	Gender	Age group
Focus Group		
1	F	18-25
2	M	26-35
3	M	26-35
4	M	26-35
5	F	26-35
6	F	26-35
Individual Interviews		
1	M	36-45
2	M	46-55
3	F	46-55
4	M	56-65

Both techniques followed the same structure of questions. First, two general questions have been introduced, which were related to how participants perceive the term fairness in the field of road safety, while the second one is related to their opinion about the importance of fairness of road safety policies in the decision-making process.

Furthermore, two key questions have been formulated, which consisted the main points of discussion. First, participants were asked to mention the 2 or 3 suggestions to ensure designing and choosing a more fair road safety policy. The second question included a rating task, were participants were asked to rate statements about the following ethical perspectives related to road safety:

- Whether fairness should be included in the decision-making process, or only effectiveness
- Risk exposure of road users
- Risk-prone road users vs risk-exposed road users
- Who pays for the benefits and who receives them
- Income group of road users
- Spatial equity
- Age group of road users

The main attributes that were identified in the preliminary research to be included in the Distributional Fairness Perception experiment, are divided in three categories as follows (see Figure 2).

Distribution of road safety benefits:

- Spatial distribution
- Distribution to the different road user types
- Distribution to the different age groups

Distribution of monetary costs:

- Distribution to the different road user types
- Distribution to the different income groups

Distribution of non-monetary negative externalities:

- Distribution to the different road user types
- Distribution to the different age groups

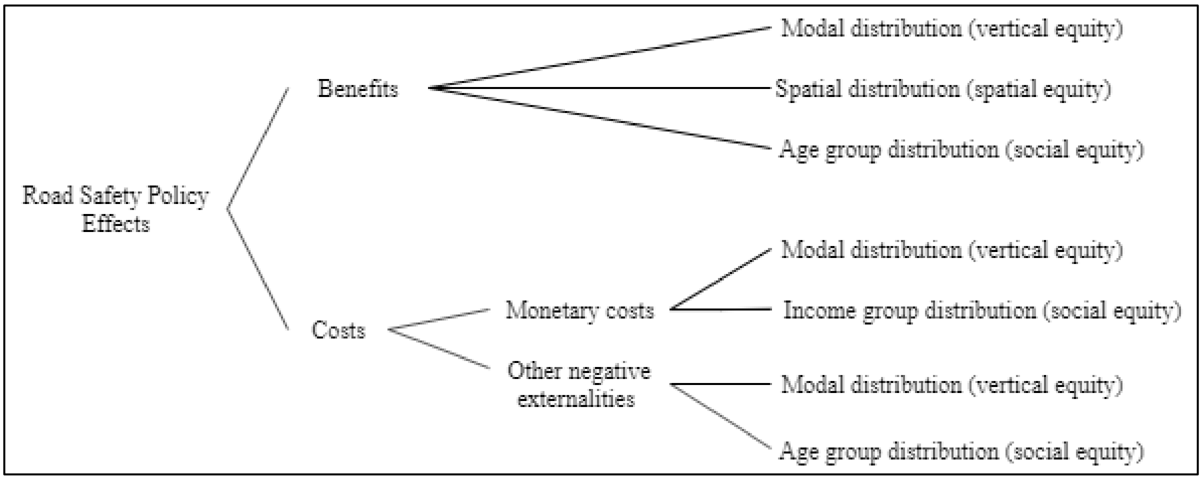

Figure 2 – Important aspects related to the distribution of effects of road safety policies

As regards the Road Safety Policy Choice experiment, the aggregate magnitude of those effects together with the perception of distributional fairness are going to be included in the design of the experiment. Moreover, another factor that has been identified in the preliminary research is the current level of fatalities. This factor will be included as an interaction effect to the importance of fairness, based on the hypothesis that the higher the current number of road fatalities, the more people focus on the effectiveness of a policy.

Finally, there were more aspects that have been identified from the preliminary research. Those factors are non-distributional related aspects that might affect people's perception of distributional fairness, or the extent up to which they are willing to trade it with other aspects of road safety policies. Those aspects are policy related aspects:

- Type of road safety policy (e.g. infrastructure, regulation etc.)
- Scale of the focus area of the road safety policy (e.g. national, regional, neighborhood etc.)
- How the monetary costs are paid (paid directly by the road users or by government via taxation)
- Level of participation of different groups of citizens in the design and decision-making process

Unfortunately, as regards the policy characteristics that influence the perception of distributional fairness, they have been chosen not to be included as attributes in the experiment because they are increasing its complexity exponentially. This is because for every different attribute level that is included, a new choice experiment is necessary, because the different levels would require having different values in the traded-off aspects of the policies, like cost or reduction in fatalities. For example, a different scale of cost values would be required for a national scale policy than for one that focuses in a specific urban area, in order to have realistic alternatives in the choice sets.

For that reason, the policy characteristics were chosen either not to be included or to be fixed in a specific attribute level for both the rating and the choice experiment. Since the aim of this study is to explore the people's preferences from the citizens' perspective, only the aspects related to this matter where chosen to be included. Hence, the context for both the experiments will be "a national road safety policy, where the costs are paid from the government via taxation". The type of the policy and the level of participation of people are not going to have an added-value contribution to this study if they are included as a fixed value.

5. Experimental Design

As mentioned above, only the aspects related to the distribution of road safety policy effects are going to be included as attributes in the rating experiment. In order to include them they first need to be translated into attributes and to select their necessary attribute levels. For each attribute there will be an attempt to connect the attribute levels with the ethical theories, mentioned above, but also keep the choices as simple and realistic as possible, based also on findings from the preliminary research, in order to be clear for the respondents that have no background knowledge on the topic. Below all the relevant attributes of the rating experiment and their attribute levels are presented.

Table 2 – Rating experiment attributes and attribute levels

Attributes	Levels
Road Safety Benefits	
Spatial Distribution	1. Proportionally to fatalities
	2. Only to disadvantaged
	3. Equally
Distribution to modes	1. Focus on vulnerable road users
	2. Focus on public transport users
	3. Focus on car users
	4. Focus on all road users equally
Distribution to age groups	1. Focus on young age groups
	2. Focus on the elderly
	3. Focus on all age groups equally
Monetary Costs	
Distribution to modes	1. Paid by car users
	2. Paid by all road users
Distribution to income groups	1. Distributed equally to all income groups
	2. Distributed proportionally to income
	3. Distributed progressively to income
Non-monetary Externalities	
Distribution to modes	1. Allocated to vulnerable road users
	2. Allocated to public transport users
	3. Allocated to car users
	4. Allocated to all road users equally
Distribution to age groups	1. Allocated to young age groups
	2. Allocated to the elderly
	3. Allocated to all age groups equally

In the choice experiment, the attributes that are going to be included are related to the aspects that are traded-off with distributional fairness. In order to include those aspects in the design they need to be translated into attributes and also to select the most appropriate attribute levels, as it has been done with the rating experiment. For each attribute there will be an attempt to keep the choices as simple and realistic as possible in order to be clear for respondents that have no background knowledge on the topic. Below all the relevant attributes of the choice experiment and their attribute levels are presented.

Table 3 – Choice experiment attributes and attribute levels

Attributes	Unit	Levels
Cost	Million Euro	1, 5, 10
Effectiveness	Fatalities saved	5, 10, 15
Non-monetary externalities	Minutes of average travel time increase	5, 10, 15
Distributional fairness	Perception rating from 1 to 5	1, 3, 5

For both experiments an orthogonal fractional factorial design has been chosen in order to ensure the orthogonality of the experimental design. The first experiment requires a minimum of 36 profiles, while the second only 12, which have been designed using the Ngene software (ChoiceMetrics, 2012). Optimally the preferred number of tasks per respondent is around 10-12 rating and 10-12 choice tasks. Therefore those 36 profiles of the first experiment are divided in 3 blocks of 12 profiles, and every respondent will answer only one of those blocks.

After removing 4 choice sets that included a dominant alternative, each respondent has to perform a total of 12 rating tasks and 8 choice tasks. Each task represents one of the constructed profiles from the experimental designs mentioned above, which vary from each other in terms of attribute levels. For the rating task all the profiles have been constructed based on the table version that has been used in the pilot survey, and is shown in Figure 3 below. On the other hand, the different alternatives of the choice task profiles together with the opt-out question are presented in Figure 4.

Road Safety Policy 1:

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Figure 3 – Rating task profile example

Choice task 1:

Road Safety Policy Characteristics	Option A	Option B
Cost	5,000,000 €	10,000,000 €
Reduction of fatalities	5 persons/year	10 persons/year
Average increase in travel times per person per day	10 min	10 min
Your Fairness Perception	3 (out of 5)	1 (out of 5)

a. Which of the two road safety policies do you think is better, if the total number of road fatalities in the country last year was **700** persons?

○ Option A
○ Option B

b. Would you **vote** for the government to implement this policy?
○ Yes, I would like it to be added to the government's current road safety policy program.
○ No, I think the government should keep its current road safety policy program as it is now.

Figure 4 – Choice task profile example

6. Data Collection and Analysis

The Stated Preference experiment took place from the 13th of September to the 5th of October 2019. From this process the responses for a sample of 64 participants have been gathered. From those 64 participants, 28% (18 respondents) completed the first block, 42% (27 respondents) the second block, and 30% (19 respondents) the third block. The descriptive statistics of the sociodemographic characteristics of the sample are presented in Table 4.

The responses of the sample have been then analysed in order to estimate, firstly, the Linear Regression models for the Distributional Fairness Perception experiment, and secondly the Discrete Choice models for the Road Safety Policy Choice experiment.

As regards the Linear Regression, this method assumes a linear relationship between the dependent variable, which in this case is the Perceived Distributional Fairness, and the independent variables, which are the attributes of the experiment. This relationship can be expressed with the following formula:

$$Yi = c + \sum(\beta i * Xi)$$

Where Y_i is the dependent variable (Perceived Distributional Fairness), c is a regression constant, and β_i is the parameter for each dependent variable X_i.

Since all attributes are nominal, they need to be dummy coded. For each one of the attributes the reference level for the dummy coding has been chosen to be the equal distribution or the allocation to all road users. The estimated parameters of both Linear Regression models are presented in Table 5. By taking a look at the R^2 of both models it can be concluded that the second model, where the interactions with sociodemographic variables have been included, has a better model fit than the one without them.

Table 4 – Sociodemographic characteristics of the sample

Sociodemographic characteristics	Categories	% of respondents (number of respondents)
Gender	Male	67% (43)
	Female	31% (20)
	Unknown	2% (1)
Age	18 – 25	24% (15)
	26 – 35	59% (38)
	36 – 45	6% (4)
	46 – 55	3% (2)
	> 55	3% (2)
	Unknown	5% (3)
Education	High School	8% (5)
	Bachelor's Degree	19% (12)
	Master's Degree	69% (44)
	PhD Degree	5% (3)
Driver's License		83% (53)
Car availability		47% (30)
Income	<10,000	14% (9)
	10,000 – 20,000	9% (6)
	20,000 – 30,000	16% (10)
	30,000 – 40,000	9% (6)
	40,000 – 50,000	8% (5)
	50,000 – 60,000	6% (4)
	60,000 – 70,000	3% (2)
	70,000 – 80,000	6% (4)
	> 80,000	9% (6)
	Unknown	19% (12)

Table 5 – Distributional Fairness Perception model estimation without and with sociodemographic variables

Parameter	Linear Regression		Linear Regression - Sociodemographic	
	Estimation	t-value	Estimation	t-value
C	3.122	18.665	2.911	12.310
Road Safety Benefits				
Spatial Distribution (SDB)				
Proportional	0.378	3.742	0.361	3.207
Only to disadvantaged	0.269	2.664	0.317	2.810
Equal (ref.)	0.000		0.000	
Distribution to modes (MDB)				
Vulnerable road users	-0.041	-0.355	-0.038	-0.296
Public transport users	0.044	0.235	-0.022	-0.105
Car users	-0.364	-2.636	-0.413	-2.664
All road users (ref.)	0.000		0.000	
Distribution to age groups (ADB)				
Young	-0.181	-1.792	-0.131	-1.097
Elderly	-0.173	-1.709	-0.138	-1.156
All age groups (ref.)	0.000		0.000	
*Distribution to age groups (ADB) *children*				
Young			-0.228	-0.609
Elderly			-0.303	-0.811
Monetary Costs				
Distribution to modes (MDC)				
Car users	-0.101	-0.864	-0.197	-1.283
All road users (ref.)	0.000		0.000	
*Distribution to modes (MDC) * car_ownership*				
Car users			0.066	0.352
Distribution to income groups (IDC)				
Proportionally	0.472	-2.968	0.857	3.943
Progressively	0.299	1.710	0.557	2.579
Equal (ref.)	0.000		0.000	
*Distribution to income groups (IDC) * income*				
Proportionally			-0.075	-1.699
Progressively			-0.052	-1.197
Non-monetary Externalities				
Distribution to modes (MDE)				
Vulnerable road users	-0.427	-3.659	-0.341	-2.216
Public transport users	-0.437	-2.327	-0.345	-1.399
Car users	-0.143	-1.035	0.048	0.274
All road users (ref.)	0.000		0.000	

Table 5 –Distributional Fairness Perception model estimation without and with sociodemographic variables (cont'd)

Parameter	**Linear Regression**		**Linear Regression - Sociodemographic**	
	Estimation	**t-value**	**Estimation**	**t-value**
*Distribution to modes (MDE) * commuter*				
Vulnerable road users			-0.023	-0.078
Public transport users			-0.005	-0.017
Car users			-0.506	-1.773
Distribution to age groups (ADE)				
Young	-0.303	-2.995	-0.336	-2.792
Elderly	-0.240	-2.372	-0.146	-1.216
All age groups (ref.)	0.000		0.000	
*Distribution to age groups (ADE) * children*				
Young			0.325	0.863
Elderly			-0.563	-1.495
car_ownership			-0.287	-2.009
income			0.030	0.949
commuter (dummy)			-0.010	-0.046
children (dummy)			0.926	2.664
n	64		50	
R^2	0.1115		0.1722	

As regards the choice experiment for the preference over different road safety policy alternatives, the main method of this study, namely the Discrete Choice Approach, is going to be followed. In this study the Random Utility Maximization (RUM) theory firstly introduced by McFadden (1973) will be applied. This theory assumes that people choose the alternative of a specific choice set that give them the highest utility. The utility of each alternative is influenced by several factors that consist the attributes of the choice experiment and can be described by the following expression.

$$U_i = V_i + \varepsilon_i = \sum_m \beta_m x_{im} + \varepsilon_i$$

Where U_i is the total utility of alternative i, V_i is the systematic utility, ε_i is the random utility, x_{im} is the value of attribute m of alternative i, and β_m is the importance of attribute m to the systematic utility.

Based on the RUM theory two models will be initially estimated, one simple Multinomial Logistic Regression (MNL) model and a panel effect Mixed Logit (ML) model. After that the one that fits better will be further analysed in order to add the interaction effects of perceived distributional fairness with the other attributes of the choice experiment. Those models are going to be used in order to estimate the importance of each attribute to the choice of people regarding different road safety policy alternatives.

The interaction effects of perceived distributional fairness with the other attributes will show how an increase in the level of distributional fairness perception can influence the importance of the other attributes. In other words, by including the interaction effects it is possible to observe whether a reduction of fairness can be compensated with an increase of the benefits, or a reduction of the costs of a road safety policy.

Table 6 – Road Safety Policy Choice model estimation

Parameter	MNL		Panel ML		Panel ML - PDF interactions	
	Est.	t-value	Est.	t-value	Est.	t-value
Constant (ASC)	-1.579	-3.54	-1.352	-2.65	-6.281	-4.71
Cost (COST)	0.284	2.25	0.325	1.28	1.154	2.80
Effectiveness (EFF)	0.320	2.07	0.346	1.83	0.210	0.72
Negative Externalities (TT)	-0.034	-0.37	-0.076	-0.75	1.205	3.36
Perceived Distributional Fairness (PDF)	0.310	5.98	0.404	5.71	2.507	4.91
Current level of fatalities * Effectiveness (FAT * EFF)	0.044	0.76	0.098	1.41	0.122	1.73
Cost * income (COST * income)	-0.052	-3.14	-0.082	-1.74	-0.084	-1.77
Cost * Perceived Distributional Fairness (COST * PDF)					-0.414	-3.54
Effectiveness * Perceived Distributional Fairness (EFF * PDF)					0.065	0.81
Negative Externalities * Perceived Distributional Fairness (TT * PDF)					-0.536	-4.10
SigmaCOST			0.703	5.33	0.730	5.45
SigmaEFF			0.335	2.40	0.331	2.46
SigmaPDF			0.220	2.58	0.244	2.90
0-LL	-457.0227		-457.0227		-457.0227	
Final-LL	-423.5754		-384.8129		-375.3024	
McFadden's ρ^2	0.0732		0.1580		0.1788	
n = 52						

In order to compare models that are nested (one model contains all the attributes of the other model), to see which one has a better model fit, it is not sufficient to only compare the McFadden's ρ2. It is necessary to perform the Likelihood Ratio test in order to examine whether the one with the biggest McFadden's ρ2 fits better due to coincidence or not. This requires testing whether the Likelihood Ratio Statistic (LRS), which is calculated with the following equation, is bigger than the χ^2 probability value for the difference in the degrees of freedom (number of additional estimated parameters) of the two nested models.

$$LRS = 2 * (LLB - LLA)$$

For the MNL and the first ML model, the LRS is equal to 2* (-384.8129 – (-423.5754)) = 77.525, and thus larger than 16.266 which is the critical value for degrees of freedom equal to 3 and a confidence level of 0.001. Therefore, the ML model has a better model fit than the first one.

Finally, regarding the model fit of the last model, it is observed that it has a slightly better McFadden's ρ^2, which indicates that it probably has a better model fit that the previous ML model. In this case the LRS is equal to 2 * (-376.0969 – (-384.8129)) = 17.432, which is again larger than 16.266, the critical value for degrees of freedom equal to 3 and a confidence level of 0.001. Therefore, it can be concluded that the last model has the best model fit compared to both the other two models.

7. Results

In this section the results from the data analysis and the model estimations for both the Distributional Fairness Perception and the Road Safety Policy Choice experiment are presented.

7.1. Distributional Fairness Perception model results

First, the influence of the different types of distributions of the effects of road safety policies on the perception of Distributional Fairness is discussed below.

Road Safety Benefits

Spatial Distribution. None of the different types of spatial distribution has a negative effect to the perception of distributional fairness compared to the equal distribution of the road safety benefits to the different regions. Focusing on the different regions based on their current level of fatalities and allocating the road safety benefits proportionally to those regions is considered the most fair type of spatial distribution of road safety benefits.

Distribution to modes. Aiming on increasing safety only for the car users has been proved to have a negative impact on the perception of distributional fairness. On the other hand, focusing on the vulnerable road users or the public transport users has no added-value in the fairness perception compared to focusing on all the road users equally. Hence, those distributions can be considered to be perceived as more or less equally fair.

Distribution to age groups. As regards the distribution of the road safety benefits to the different age groups, focusing on saving specific age groups is perceived to be relatively unfair compared to focusing on all road users regardless of their age.

Monetary Costs

Distribution to modes. Allocating the monetary costs to implement a road safety policy to all citizens is considered to be more fair compared to allocating them only to the car users, as a tax imposed to car owners. Especially for car owners, this negative perception regarding fairness is more intense compared to those that do not own a car.

Distribution to income groups. As regards the allocation of the monetary costs to the different income groups, the most fair type of distribution has been observed to be the proportional distribution where the road users, on which the tax will be imposed based on the distribution above, pay the same percentage of their income. The second most fair distribution is the progressive distribution, where road users pay a higher percentage of their income as their income increases. Finally, what need to be also considered is that as income increases these types of distributions have a lower impact to fairness perception. However, the equal distribution is never considered more fair, even for the higher income groups.

Non-monetary Externalities

Distribution to modes. Allocating the non-monetary externalities (in terms of average travel time increase per day) to all modes of transport or only to car users is perceived as more fair than allocating them only to the vulnerable road users or public transport users. More specifically, when the vulnerable road users and the public transport users receive the increase in the average travel time there is a negative impact on the perception of fairness. However, if someone uses the car as a mode of transport to commute then allocating the negative externalities only to car users is perceived as the most unfair type of distribution. For this group of respondents, the equal distribution is perceived as the most fair distribution of all.

Distribution to age groups. As with the distribution of road safety benefits to the different age groups, allocating the non-monetary negative externalities in terms of reducing the mobility of either the young age groups or the elderly is considered to be unfair compared to allocating them equally to all age groups.

7.2. Road Safety Policy Choice model results

As regards the Road Safety Policy Choice experiment, the main outcome is that the distributional fairness perception has been proved to be one of the most influential aspects, together with the reduction in the total number of fatalities, regarding the preference of people for different road safety policy alternatives. Moreover, perceived distributional fairness has also an indirect impact to their preferences for different policy options, since despite its main effect, it also has an interaction with the other aspects of the policy.

More specifically, perceived distributional fairness influences the impact of the negative effects of road safety policies to the choice of people, but not the positive ones. In other words, people are willing to trade an increase in the negative effects, such as the cost or the non-monetary externalities, for an increase of the distributional fairness. However, they are not willing to trade the positive effects, which are the road safety benefits in terms of reduction in the total number of fatalities.

8. Conclusions

As literature suggests and the results of this study showed, low public acceptance can be a show-stopper for road safety policies. Looking only at the aggregate effects of a road safety policy can be often misleading. The way that the effects of road safety policies are distributed among different groups of people can have a significant influence on the public acceptance of road safety policies, since they influence the perception of distributional fairness of the policy. Moreover, several characteristics of the people have shown an influence on the way that they perceive what is fair or not. Therefore, it also important to consider the characteristics of the population that is going to be affected by a specific road safety policy measure.

This study has also shown that the Discrete Choice Approach can actually give some insight to moral dilemmas as literature suggests (see Chorus, 2015). One of the most important findings of this study is that people are actually more willing to accept a policy that is more expensive or results in larger negative effects if they think that the effects of this policy are distributed in a more fair manner. However, they are not willing to trade all aspects of a policy for an increase on distributional fairness. The effectiveness of a road safety policy, i.e. the total number of road fatalities saved, has been proved to be one of the hard constrains for road safety policies.

9. Discussion

Despite its aforementioned contribution, this study has also several limitations. First of all, as regards the preliminary research, and more specifically, the focus groups discussion the main limitation is that it has been conducted including only students of the Delft University of Technology. Even though this ensured having a successful session, where participants feel confident to participate, it resulted into leaving out other sociodemographic groups that could possibly provide with a different perspective or insights, resulting in identifying aspects that might have been omitted from this study.

Moreover, the main experiment of this study was substitute to several limitations. The first one is related to the aspects that indirectly influence the distributional fairness perception of road safety policies and have been either omitted from the experiment or they have been fixed to a specific value. However, it would be interesting to see how the perception would be influenced by these aspects, even though they will result in a larger experimental design.

Another limitation regarding the experimental design is the choice to remove the types of distribution that seemed unrealistic for the road safety policies of the first experiment. This probably resulted in a worse model fit, due to the limited information regarding the lower part of the scale of the distributional fairness perception. For the Road Safety Policy Choice models, and more specifically the simple MNL and the fist ML model, the effect of negative externalities has been proved to be statistically insignificant. Therefore, this attribute doesn’t influence people’s choice. A reason for that could potentially be that the different attribute level values that have been chosen for this experiment were too close between them in order to offer enough trade-off to the respondents.

Finally, one major limitation of this study is related to the fact that respondents have been asked to evaluate the road safety policy alternatives as individual policies, and not as part of a wider road safety policy program. However, in reality this is not accurate, since policies are always part of a wider program, which consists of road safety measures of different types. To reduce the influence of this limitation the “none of the above” option has been added as an alternative, where respondents had to recommend to the government whether to add the chosen road safety policy option to the existing road safety policy program.

However, this program has not been defined, therefore individuals might not have all the necessary information to answer this question. For example, if the national road safety policy program has a specific regulation on speeding, adding a new regulation on speeding will mean that the initial one is removed, while adding a infrastructure related measure that might interact positively with the initial speeding regulation, will both keep the initial regulation in the program and increase the chance that people will want it to be added.

Another limitation of this study is the limited sample. In total out of the 130 that started the survey only 64 completed the whole questionnaire, which equals to only 49%. The small sample possibly resulted in the relatively low model fit of the Linear Regression model

Finally, one last aspect to be considered is the possibility that mostly people that consider fairness to be important in the first place took the time to consider starting and actually completing the whole survey. Therefore,

10. Recommendations

10.1. Recommendations for Future Research

Based on the aforementioned outcomes and limitations of this study, a number of recommendations is provided to researchers, that could be followed if they are interested in further investigating this specific topic. These recommendations are as follows.

First of all, conducting a different focus group discussion for each of the relevant groups of stakeholders, such as citizens, public authorities, policymakers, road safety experts etc, is recommended. From these focus groups different aspects might arise from the ones that have been already identified from the focus group discussion of this study.

As regards the data analysis, the small number of respondents in the main experiment resulted in less confidence regarding the outcomes of the models. Therefore, it is considered necessary to, at least, replicate the experiment of this study (if not improve it) with a bigger sample than the current one. If similar results are obtained, then the outcomes of this study can be considered much more reliable.

Moreover, it is recommended to consider applying different types of models to analyse the Stated Preference data. For the Distributional Fairness Perception experiment an Ordered Logit model can be estimated instead of a Linear Regression model. For the Road Safety Policy Choice experiment, on the other hand, instead of following the RUM the Random Regret Minimization (RRM) theory can be followed.

Finally, different experimental techniques, such as gamification or the Participatory Value Evaluation method in order to understand the preferences and choice behaviour of people, could be useful in order to reduce the limitations regarding the experimental design the were mentioned above.

10.2. Policy Recommendations

Finally, from the conclusions of this study, two practical recommendations are given to policymakers in order to help them make their road safety policy interventions more efficient.

The first suggestion is to promote the importance of social dialogue among all the different stakeholders related to road safety, such as road safety researchers and experts, local authorities, citizens, or associations (like the motorcyclist associations, trade associations etc.). Taking into account the preferences of people in the design and decision-making process, will have a positive impact to the public acceptability of those road safety policies.

Furthermore, this study has shown that it is not only sufficient to consider the aggregate effects or a road safety policy, but it is also necessary to take into account the way that those effects are distributed. Therefore, one suggestion to policymakers is to try to incorporate the fairness consideration of road safety policies into the decision-making process. Two ways can be found in literature that this can be done.

The first way is to include fairness considerations in the appraisal by integrating it into the existing CBA framework. One proposed method considers the use of distributional weights or equity values for the costs and benefits of different groups. However, distributional weights and equity values have been rarely used in practice (Martens, 2011).

According to Martens (2011), the use of distributional weights or equity values could indeed solve some of the limitations of CBA. However, there are two disadvantages with using distributional weights and equity values. The first one is that they still provide no information to the policymakers about how specific impacts of the alternatives are distributed among the population groups or regions. Moreover, applying weights comes in contradiction to the main principal of CBA, which is giving everyone an equal weight, since it is based on the utilitarian theory.

Therefore, the second way, which is to accompany CBA with a separate equity analysis (as suggested by Johansson-Stenman, 2000; Martens, 2011; Wortelboer-van Donselaar & Visser, 2012), that focuses on the distribution of the road safety effect that are included in the CBA, is considered a more suitable solution. This way the integrity of CBA is maintained and the added value of the information regarding distributional fairness is included effectively in the process.

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Appendix B – Focus Group Questions

<u>Introductory question</u>

"What comes to your mind when you hear the phrase "fair road safety policy"?"

<u>Transition question</u>

"Why do you think fairness is an important aspect of road safety policies?"

<u>Key questions</u>

1. Role-play task

"Imagine that you had a minute to talk to Minister of Infrastructure and Water Management on the topic of today's discussion, which is fairness of road safety policies. What would be your 2 or 3 most important suggestions to ensure designing and choosing more fair road safety policies?

2. Rating task

"Please rate the following statements related to ethical dilemmas in road safety from 1 (Totally Disagree) to 5 (Totally Agree), based on your level of agreement."

a. Policymakers should always choose road safety policies based on the total reduction in the number of fatalities. More detailed characteristics (such as the mode of transport, age, income, risk exposure etc.) of the individuals should not play a role in their decision.

b. Vulnerable road users (pedestrian, cyclists, elderly or novice drivers) are exposed to higher risks, so they should be the main focus (aim to protect them more) when designing road safety policies.

c. Risk-prone motorcyclists should not be treated equally in the distribution of benefits as the rest of the vulnerable users when designing a road safety policy, because it is their choice to expose themselves in higher risk.

d. Drivers should pay for installing an Advanced Driver Assistance System (such as Advanced Emergency Braking for pedestrians and cyclists) to their car, even though the safety benefits go to the vulnerable road users.

e. Low-income groups are forced to walk or bike because they cannot afford to buy a car. Thus, they are exposed to greater risks. For that reason, road safety policies should focus more on those groups of people.

f. Policymakers should not always choose the road safety policy that has the biggest reduction in the total number of fatalities. They should aim to distribute this reduction proportionally to the different regions, based on the current number of fatalities per region.

g. Assume that the following measure has significant road safety benefits. The minimum legal age to drive should be increased from 18 to 21 and also a maximum legal age of, for example, 75 years should be introduced, even though it reduces the mobility and accessibility of those age groups.

<u>Ending question</u>

"Considering all the things that were mentioned during this discussion, either by you or by someone else, what do you think was the most important thing that was mentioned."

"Do you think there are other aspects that people might consider for the fairness of road safety policies and were not mentioned?"

Appendix C – Individual Exploratory Research Interview Questionnaire

Delft University of Technology

MSc Transport Infrastructure and Logistics

Exploratory Research Interview

Questionnaire

Topic: Fairness of Road Safety Policies

Interview No.: _____

Date: ___/___ / 2019

Questions:

1. What comes to your mind when you hear the phrase "fair road safety policy"? Could you give an example of a fair or unfair road safety policy? Why do you think it is fair/unfair?

2. Do you think that the fair distribution of the effects of a road safety policy is an important aspect that policymakers should consider? Please explain your answer briefly.

3. Imagine that you had a minute to talk to Minister of Infrastructure and Water Management about the fairness of road safety policies. What would be your 2 or 3 most important suggestions for more fair road safety policies?

4. Please indicate your level of agreement with the following statements and briefly explain your answer. Why is it important to take these considerations into account?

a. Policymakers should always choose road safety policies based on the total reduction in the number of fatalities. More detailed characteristics (such as the mode of transport, age, income, risk exposure etc.) of the individuals should not play a role in their decision.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
○	○	○	○	○

b. Vulnerable road users (pedestrian, cyclists, elderly or novice drivers) are exposed to higher risks, so they should be the main focus (try to protect them more) when designing road safety policies.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
○	○	○	○	○

c. Risk-prone motorcyclists should not be treated equally in the distribution of benefits as the rest of the vulnerable users when designing a road safety policy, because it is their choice to expose themselves in higher risk.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
○	○	○	○	○

d. Drivers should pay for installing an Advanced Driver Assistance System (such as Advanced Emergency Braking for pedestrians and cyclists) to their car, even though the safety benefits go to the vulnerable road users.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
◯	◯	◯	◯	◯

e. Low-income groups are forced to walk or bike because they cannot afford to buy a car. Thus, they are exposed to greater risks. For that reason, road safety policies should focus more on those groups of people.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
◯	◯	◯	◯	◯

f. Policymakers should not always choose the road safety policy that has the biggest reduction in the total number of fatalities. They should aim to distribute this reduction proportionally to the different regions, based on the current number of fatalities per region.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
◯	◯	◯	◯	◯

g. Assume that the following measure has significant road safety benefits. The minimum legal age to drive should be increased from 18 to 21 and also a maximum legal age of, for example, 75 years should be introduced, even though it reduces the mobility and accessibility of those age groups.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
○	○	○	○	○

5. Do you think there are other aspect(s)/factor(s) that policymakers should be aware of and take into account in order to ensure the fairness in the distribution of effects of a road safety policy and was/were not mentioned above? Why do you think it/they are important?

6. Socio-demographic data

Gender:

- ○ Male
- ○ Female
- ○ Prefer not to say

Age:

- ○ Under 18
- ○ 18-25
- ○ 26-35
- ○ 36-45
- ○ 46-55
- ○ 56-65
- ○ 66-75
- ○ 75+
- ○ Prefer not to say

Level of Education:

- ○ Primary School
- ○ High School
- ○ College/University
- ○ Graduate School
- ○ Other ………….
- ○ Prefer not to say

Appendix D – Ngene Code Syntaxes and Generated Experimental Designs

D.1. Rating Experiment Syntax

```
? main effects only orthogonal design for distributional fairness perception
Design
; alts = pdf, base
; orth = sim
; rows = 36
; block = 3
; model:
U(pdf) = beta_spatial_distribution_benefits.dummy[0|0] * spatial_distribution_benefits[1,2,3]
+ beta_mode_distribution_benefits.dummy[0|0|0] * mode_distribution_benefits[1,2,3,4] +
beta_age_distribution_benefits.dummy[0|0] * age_distribution_benefits[1,2,3] +
beta_mode_distribution_costs * mode_distribution_costs[1,2] +
beta_income_distribution_costs.dummy[0|0] * income_distribution_costs[1,2,3] +
beta_mode_distribution_externalities.dummy[0|0|0] *
mode_distribution_externalities[1,2,3,4] +
beta_age_distribution_externalities.dummy[0|0] * age_distribution_externalities[1,2,3]
$
```

D.2. Choice Experiment Syntax

```
? interaction effects orthogonal design for the choice experiment
Design
; alts = alt1, alt2
; orth = sim
; rows = 12
; block = 3
; model:
U(alt1) = beta_cost * cost[1,2,3] +
          beta_ effectiveness * effectiveness [1,2,3] +
          beta_externalities * externalities[1,2,3] +
```

```
        beta_perceived_distributional_fairness * perceived_distributional_fairness[1,3,5] +
        beta_cost_perceived_distributional_fairness   * cost *
perceived_distributional_fairness +
        beta_ effectiveness_perceived_distributional_fairness   * effectiveness *
perceived_distributional_fairness +
        beta_externalities_perceived_distributional_fairness   * externalities *
perceived_distributional_fairness/
U(alt2) = b_cost * cost +
        beta_ effectiveness * effectiveness +
        beta_externalities * externalities +
        beta_perceived_distributional_fairness * perceived_distributional_fairness +
        beta_cost_perceived_distributional_fairness   * cost *
perceived_distributional_fairness +
        beta_ effectiveness _perceived_distributional_fairness   * effectiveness *
perceived_distributional_fairness +
        beta_externalities_perceived_distributional_fairness   * externalities *
perceived_distributional_fairness
$
```

Appendix E – Experimental Designs

E.1. Generated Experimental Design for Rating Experiment

Choice situation	spatial_distribution_benefits	mode_distribution_benefits	age_distribution_benefits	mode_distribution_costs	income_distribution_costs	mode_distribution_externalities	age_distribution_externalities	Block
1	3	1	3	1	2	1	2	3
2	2	2	2	2	1	3	3	2
3	3	1	3	1	1	3	3	2
4	2	2	2	1	2	2	2	3
5	3	3	1	2	3	4	2	2
6	1	4	3	1	2	4	1	1
7	3	3	1	1	2	2	1	1
8	1	4	3	1	3	3	2	2
9	2	1	1	2	1	4	1	3
10	1	2	2	2	3	2	3	1
11	2	3	1	2	3	1	3	1
12	1	4	2	2	1	1	1	3
13	1	1	1	1	1	1	3	1
14	3	2	3	2	3	3	1	3
15	1	1	1	1	3	3	1	3
16	3	2	3	1	1	2	3	1
17	1	3	2	2	2	4	3	3
18	2	4	1	1	1	4	2	2
19	1	3	2	1	1	2	2	2
20	2	4	1	1	2	3	3	3
21	3	1	2	2	3	4	2	1
22	2	2	3	2	2	2	1	2
23	3	3	2	2	2	1	1	2
24	2	4	3	2	3	1	2	1
25	2	1	2	1	3	1	1	2
26	1	2	1	2	2	3	2	1
27	2	1	2	1	2	3	2	1
28	1	2	1	1	3	2	1	2
29	2	3	3	2	1	4	1	1

30	3	4	2	1	3	4	3	3
31	2	3	3	1	3	2	3	3
32	3	4	2	1	1	3	1	1
33	1	1	3	2	2	4	3	2
34	3	2	1	2	1	2	2	3
35	1	3	3	2	1	1	2	3
36	3	4	1	2	2	1	3	2

E.2. Initial Generated Experimental Design for Choice Experiment

	Option A				Option B				
Choice situation	Cost	Effectiveness	Negative Externalities	Perceived Dist. Fairness	Cost	Effectiveness	Negative Externalities	Perceived Dist. Fairness	Block
1	2	1	2	3	3	2	2	1	2
2	3	3	2	5	1	1	2	1	2
3	3	3	3	1	2	2	1	3	3
4	1	2	3	1	1	3	3	5	2
5	3	1	1	1	2	1	3	3	3
6	1	1	3	5	2	1	1	3	3
7	2	3	2	3	3	1	2	5	1
8	2	2	3	3	3	3	3	1	1
9	3	1	2	5	1	2	2	5	1
10	1	2	1	1	1	3	1	1	1
11	1	3	1	5	2	2	3	3	3
12	2	2	1	3	3	3	1	5	2

E.3. Final Experimental Design for Choice Experiment

	Option A				Option B				
Choice situation	Cost	Effectiveness	Negative Externalities	Perceived Dist. Fairness	Cost	Effectiveness	Negative Externalities	Perceived Dist. Fairness	Block
1	2	1	2	3	3	2	2	1	2
2	3	3	2	5	1	1	2	1	2
3	3	3	3	1	2	2	1	3	3
5	3	1	1	1	2	1	3	3	3
6	1	1	3	5	2	1	1	3	3
7	2	3	2	3	3	1	2	5	1
8	2	2	3	3	3	3	3	1	1
12	2	2	1	3	3	3	1	5	2

Appendix F – Survey Questionnaire

F.1. Rating Tasks

F.1.1. Block 1

Part 1:

In this part of the survey you will be asked to rate **12** different road safety policies on **HOW FAIR** you think they are from 1 (**unfair**) to 5 (**fair**). The differences of the policies are going to be given in **bold letters**, and are related to **the way that the policy effects are distributed.** Those effects will be the safety benefits in terms of reduction in the number of fatalities, the costs to implement the policy, and other negative effects, like travel time increase and reduction of mobility (how able and encouraged people will feel to travel). Please also note that all of the policies are national road safety policies and the costs to implement them are paid by the government with money that come through taxation.

Please, keep in mind that wherever you see the asterisk symbol (*) there is further explanation provided via a **hypertext.**

1. **Road Safety Policy 1:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2. **Road Safety Policy 2:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Young**	**Car** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. **Road Safety Policy 3:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Elderly**	**Public transport** users	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Progressively** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4. **Road Safety Policy 4:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Young**	**Car** users	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**All** age groups		

Travel time increase	**Vulnerable** road users*	

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. **Road Safety Policy 5:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Young**	**Vulnerable** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**All** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

6. **Road Safety Policy 6:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Public transport** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**All** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. **Road Safety Policy 7:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**Vulnerable** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Progressively** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8. **Road Safety Policy 8:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**All** road users*		**Progressively** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. **Road Safety Policy 9:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Young**	**Public transport** users	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**Elderly** age groups		

Travel time increase	**Car** users	

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10. **Road Safety Policy 10:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Elderly**	**Vulnerable** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11. **Road Safety Policy 11:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**All** age groups	**Car** users	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. **Road Safety Policy 12:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Elderly**	**All** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**Young** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

F.1.2. Block 2

Part 1:

In this part of the survey you will be asked to rate **12** different road safety policies on **HOW FAIR** you think they are from 1 (**unfair**) to 5 (**fair**)**.** The differences of the policies are going to be given in **bold letters**, and are related to **the way that the policy effects are distributed.** Those effects will be the safety benefits in terms of reduction in the number of fatalities, the costs to implement the policy, and other negative effects, like travel time increase and reduction of mobility (how able and encouraged people will feel to travel)**.** Please also note that all of the policies are national road safety policies and the costs to implement them are paid by the government with money that come through taxation.

Please, keep in mind that wherever you see the asterisk symbol (*) there is further explanation provided via a **hypertext.**

1. **Road Safety Policy 1:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Elderly**	**Public transport** users	**Proportionally** on each region of the country*
Costs are allocated to...	**All** road users*		**Equally***
Mobility reduction	**All** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2. **Road Safety Policy 2:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**All** age groups	**Vulnerable** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**All** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. **Road Safety Policy 3:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**Young**	**Car** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Progressively** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4. **Road Safety Policy 4:**

Policy Effects	Who is affected?		How are they distributed?
The aim is to reduce the fatalities of...	**All** age groups	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**Elderly** age groups		

Travel time increase	**Car** users	

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. **Road Safety Policy 5:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Young**	**All** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**Elderly** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

6. **Road Safety Policy 6:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**Car** users	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Equally***
Mobility reduction	**Elderly** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. **Road Safety Policy 7:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Public transport** users	**Proportionally** on each region of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8. **Road Safety Policy 8:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**Car** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. **Road Safety Policy 9:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**Vulnerable** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**Young** age groups		

Travel time increase	**Vulnerable** road users*	

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10. **Road Safety Policy 10:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Young**	**Public transport** users	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11. **Road Safety Policy 11:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Vulnerable** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. **Road Safety Policy 12:**

Policy Effects	**Who is affected?**		**How are they distributed?**
The aim is to reduce the fatalities of...	**Young**	**All** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

F.1.3. Block 3

Part 1:

In this part of the survey you will be asked to rate **12** different road safety policies on **HOW FAIR** you think they are from 1 (**unfair**) to 5 (**fair**). The differences of the policies are going to be given in **bold letters**, and are related to **the way that the policy effects are distributed.** Those effects will be the safety benefits in terms of reduction in the number of fatalities, the costs to implement the policy, and other negative effects, like travel time increase and reduction of mobility (how able and encouraged people will feel to travel). Please also note that all of the policies are national road safety policies and the costs to implement them are paid by the government with money that come through taxation.

Please, keep in mind that wherever you see the asterisk symbol (*) there is further explanation provided via a **hypertext.**

1. **Road Safety Policy 1:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Vulnerable** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2. **Road Safety Policy 2:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**Public transport** users	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**Elderly** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. **Road Safety Policy 3:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**Young**	**Vulnerable** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**All** road users*		**Equally***
Mobility reduction	**Young** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4. **Road Safety Policy 4:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**Elderly**	**All** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Equally***
Mobility reduction	**Young** age groups		

Travel time increase	**Vulnerable** road users*	

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. **Road Safety Policy 5:**

Policy Effects	Who is affected?		How is it distributed?
The aim is to reduce the fatalities of...	**All** age groups	**Public transport** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Progressively** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

6. **Road Safety Policy 6:**

Policy Effects	Who is affected?		How is it distributed?
The aim is to reduce the fatalities of...	**Young**	**Vulnerable** road users*	**Equally** on all regions of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**Young** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. **Road Safety Policy 7:**

Policy Effects	Who is affected?		How is it distributed?
The aim is to reduce the fatalities of...	**Elderly**	**Car** users	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Proportionally** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8. **Road Safety Policy 8:**

Policy Effects	Who is affected?		How is it distributed?
The aim is to reduce the fatalities of...	**Young**	**All** road users*	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Proportionally** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**Car** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. **Road Safety Policy 9:**

Policy Effects	Who is affected?		How is it distributed?
The aim is to reduce the fatalities of...	**Elderly**	**All** road users*	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**All** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10. **Road Safety Policy 10:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Car** users	**Proportionally** on each region of the country*
Costs are allocated to...	**Car** users		**Progressively** to their income*
Mobility reduction	**All** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11. **Road Safety Policy 11:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**Young**	**Public transport** users	**Only** to the **most disadvantaged** regions of the country*
Costs are allocated to...	**All** road users*		**Equally***
Mobility reduction	**Elderly** age groups		
Travel time increase	**Public transport** users		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. **Road Safety Policy 12:**

Policy Effects	**Who is affected?**		**How is it distributed?**
The aim is to reduce the fatalities of...	**All** age groups	**Car** users	**Equally** on all regions of the country*
Costs are allocated to...	**All** road users*		**Equally***
Mobility reduction	**Elderly** age groups		
Travel time increase	**Vulnerable** road users*		

Please, rate this road safety policy on how fair you think it is from 1 (**unfair**) to 5 (**fair**) based on those characteristics.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

F.2. Choice Tasks

F.2.1. Block 1

Part 2:

This part of the survey consists of **8** choice tasks. For each one you are asked to choose the road safety policy that you prefer over two alternatives. Each choice will differ in terms of cost, the number in reduction of fatalities that will cause, the average increase in travel times (in minutes per person per day) after implementing it, and finally in **your perception** of fairness, as you would have rated the policy in the previous rating task.

After each choice that you make you will also have to imagine that the government is having a **referendum** because it is considering adding that policy to its current road safety policy program. You will be then asked if you would **vote** in favor of the policy you have just chosen, or if you prefer the government to keep the current road safety program as it is.

1. **Choice task 1:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 5 persons/year 10 min 3 (out of 5)	10,000,000 € 10 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

2. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

3. **Choice task 2:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 10 min 5 (out of 5)	1,000,000 € 5 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

4. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

5. **Choice task 3:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 15 min 1 (out of 5)	5,000,000 € 10 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A

☐ Option B

6. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

7. **Choice task 4:**

Road Safety Policy Characteristics	**Option A**	**Option B**
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 5 persons/year 5 min 1 (out of 5)	5,000,000 € 5 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

8. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

9. **Choice task 5:**

Road Safety Policy Characteristics	**Option A**	**Option B**
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	1,000,000 € 5 persons/year 15 min 5 (out of 5)	5,000,000 € 5 persons/year 5 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

10. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

11. **Choice task 6:**

Road Safety Policy Characteristics	**Option A**	**Option B**
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 15 persons/year 10 min 3 (out of 5)	10,000,000 € 5 persons/year 10 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

12. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

13. **Choice task 7:**

Road Safety Policy Characteristics	**Option A**	**Option B**

Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 15 min 3 (out of 5)	10,000,000 € 15 persons/year 15 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

14. b. Would you **vote** for the government to implement this policy?
☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

15. **Choice task 8:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 5 min 3 (out of 5)	10,000,000 € 15 persons/year 5 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

16. b. Would you **vote** for the government to implement this policy?
☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

F.2.2. Block 2

Part 2:

This part of the survey consists of **8** choice tasks. For each one you are asked to choose the road safety policy that you prefer over two alternatives. Each choice will differ in terms of cost, the number in reduction of fatalities that will cause, the average increase in travel times (in minutes per person per day) after implementing it, and finally in **your perception** of fairness, as you would have rated the policy in the previous rating task.

After each choice that you make you will also have to imagine that the government is having a **referendum** because it is considering adding that policy to its current road safety policy program. You will be then asked if you would **vote** in favor of the policy you have just chosen, or if you prefer the government to keep the current road safety program as it is.

1. **Choice task 1:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 5 persons/year 10 min 3 (out of 5)	10,000,000 € 10 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

2. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

3. **Choice task 2:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 10 min 5 (out of 5)	1,000,000 € 5 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

4. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

5. **Choice task 3:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 15 min 1 (out of 5)	5,000,000 € 10 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A

☐ Option B

6. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

7. **Choice task 4:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 5 persons/year 5 min 1 (out of 5)	5,000,000 € 5 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

8. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

9. **Choice task 5:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	1,000,000 € 5 persons/year 15 min 5 (out of 5)	5,000,000 € 5 persons/year 5 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

10. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

11. **Choice task 6:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 15 persons/year 10 min 3 (out of 5)	10,000,000 € 5 persons/year 10 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

12. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

13. **Choice task 7:**

Road Safety Policy Characteristics	Option A	Option B

Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 15 min 3 (out of 5)	10,000,000 € 15 persons/year 15 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

14. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

15. **Choice task 8:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 5 min 3 (out of 5)	10,000,000 € 15 persons/year 5 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

16. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

F.2.3. Block 3

Part 2:

This part of the survey consists of **8** choice tasks. For each one you are asked to choose the road safety policy that you prefer over two alternatives. Each choice will differ in terms of cost, the number in reduction of fatalities that will cause, the average increase in travel times (in minutes per person per day) after implementing it, and finally in **your perception** of fairness, as you would have rated the policy in the previous rating task.

After each choice that you make you will also have to imagine that the government is having a **referendum** because it is considering adding that policy to its current road safety policy program. You will be then asked if you would **vote** in favor of the policy you have just chosen, or if you prefer the government to keep the current road safety program as it is.

1. **Choice task 1:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 5 persons/year 10 min 3 (out of 5)	10,000,000 € 10 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

2. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

3. **Choice task 2:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 10 min 5 (out of 5)	1,000,000 € 5 persons/year 10 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

4. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

5. **Choice task 3:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 15 persons/year 15 min 1 (out of 5)	5,000,000 € 10 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A

☐ Option B

6. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

7. **Choice task 4:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	10,000,000 € 5 persons/year 5 min 1 (out of 5)	5,000,000 € 5 persons/year 15 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

8. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

9. **Choice task 5:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	1,000,000 € 5 persons/year 15 min 5 (out of 5)	5,000,000 € 5 persons/year 5 min 3 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **700** persons?

☐ Option A
☐ Option B

10. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

11. **Choice task 6:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 15 persons/year 10 min 3 (out of 5)	10,000,000 € 5 persons/year 10 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

12. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

13. **Choice task 7:**

Road Safety Policy Characteristics	Option A	Option B

Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 15 min 3 (out of 5)	10,000,000 € 15 persons/year 15 min 1 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **1000** persons?

☐ Option A
☐ Option B

14. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

15. **Choice task 8:**

Road Safety Policy Characteristics	Option A	Option B
Cost Reduction of fatalities Average increase in travel times per person per day Your Fairness Perception	5,000,000 € 10 persons/year 5 min 3 (out of 5)	10,000,000 € 15 persons/year 5 min 5 (out of 5)

a. Which of the two road safety policies do you prefer, if the total number of road fatalities in the country last year was **400** persons?

☐ Option A
☐ Option B

16. b. Would you **vote** for the government to implement this policy?

☐ Yes, I would like it to be added to the government's current road safety policy program.
☐ No, I think the government should keep its current road safety policy program as it is now.

F.3. Sociodemographic questions

Part 3:

This is the third and last part of the survey. In this part you are asked to answer a few sociodemographic questions. If you do not feel comfortable answering one question you can either leave it blank or check the "Prefer not to say" option.

1. 1. Gender:
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to say

2. 2. Your year of birth: ☐

3. 3. What is your nationality? ☐

4. 4. What is your current household composition? Please, specify the number of persons in each of the following categories.

	0	1	2	3	4 or more	Prefer not to say
Children (0-15 years old)	☐	☐	☐	☐	☐	☐
Young people (16-25 years old)	☐	☐	☐	☐	☐	☐
People between 26-45 years old	☐	☐	☐	☐	☐	☐
People between 46-65 years old	☐	☐	☐	☐	☐	☐
Elderly (65+ years old)	☐	☐	☐	☐	☐	☐

5. 5. Do you currently own a driver's license? ☐ Yes ☐ No

6. 6. Is there a car available in your household that you have access to? ☐ Yes ☐ No

7. 7. How often do you use every week each of the following modes of transport for **short** trips (**inside urban areas**)?

	Never	Less than 1 time per week	1-3 days per week	4-6 days per week	Every day	Prefer not to say
Walking	☐	☐	☐	☐	☐	☐
Bike	☐	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐	☐
Public Transport	☐	☐	☐	☐	☐	☐
Car	☐	☐	☐	☐	☐	☐

8. 8. How often do you use every week each of the following modes of transport for **long** trips (**to go outside urban areas or travel between cities**)?

	Never	Less than 1 time per week	1-3 days per week	4-6 days per week	Every day	Prefer not to say
Walking	☐	☐	☐	☐	☐	☐
Bike	☐	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐	☐
Public Transport	☐	☐	☐	☐	☐	☐
Car	☐	☐	☐	☐	☐	☐

9. 9. How often do you use every week each of the following modes of transport to go and return from your **work**?

	Never	Less than 1 time per week	1-3 days per week	4-6 days per week	Every day	Prefer not to say
Walking	☐	☐	☐	☐	☐	☐
Bike	☐	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐	☐

Public Transport	☐	☐	☐	☐	☐	☐
Car	☐	☐	☐	☐	☐	☐

10. 10. What is the highest level of education you have completed by this moment?

☐ Primary school
☐ High School
☐ Technical / Vocational Training
☐ Bachelor's degree (or equivalent)
☐ Master's degree (or equivalent)
Other, please specify:
☐ [ ]
☐ Prefer not to say

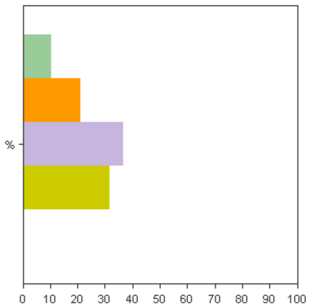
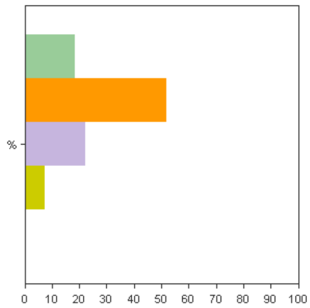
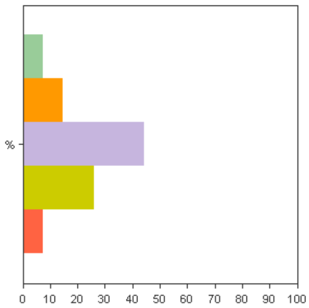
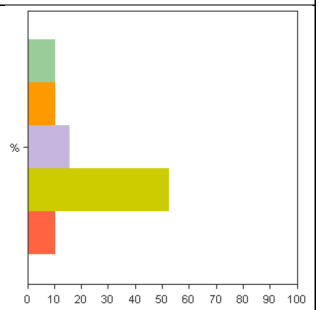
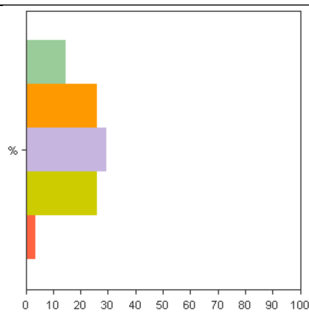
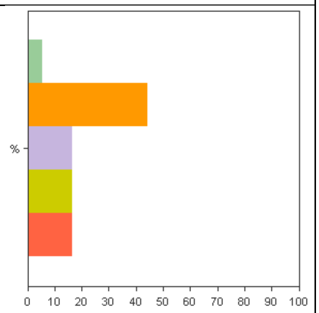
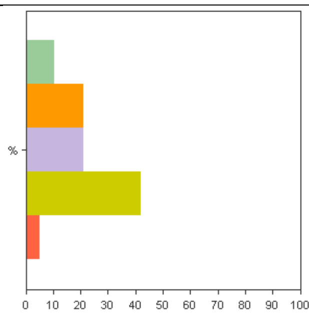
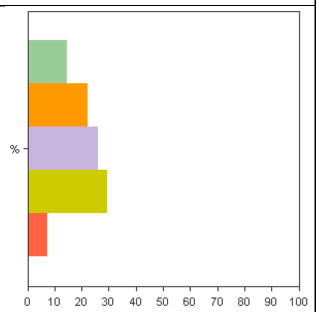
11. 11. What is the total gross annual income of your household?

☐ less than 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
☐ more than 90.000 Euro
☐ Prefer not to say

Appendix G – Descriptive Statistics of Rating Experiment

Legend:

Fairness scores 1 2 3 4 5

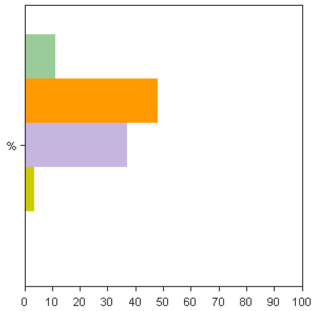
Road Safety Policy	Distribution of answers	Road Safety Policy	Distribution of answers
Profile 1 Block: 3 Respondents: 19 Average score: 2.9 ± 1.0		Profile 19 Block: 2 Respondents: 27 Average score: 2.2 ± 0.8	
Profile 2 Block: 2 Respondents: 27 Average score: 3.1 ± 1.0		Profile 20 Block: 3 Respondents: 19 Average score: 3.4 ± 1.2	
Profile 3 Block: 2 Respondents: 27 Average score: 2.8 ± 1.1		Profile 21 Block: 1 Respondents: 18 Average score: 2.9 ± 1.3	
Profile 4 Block: 3 Respondents: 19 Average score: 3.1 ± 1.1		Profile 22 Block: 2 Respondents: 27 Average score: 2.9 ± 1.2	

Profile 5

Block: 2

Respondents: 27

Average score: 2.3 ± 0.7

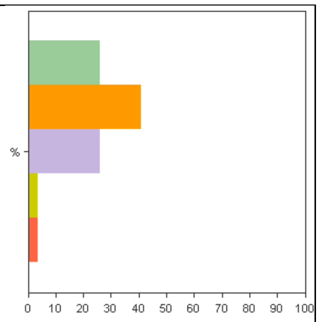


Profile 23

Block: 2

Respondents: 27

Average score: 2.2 ± 1.0

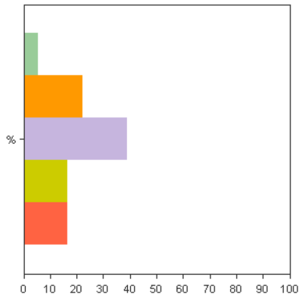


Profile 6

Block: 1

Respondents: 18

Average score: 3.2 ± 1.2

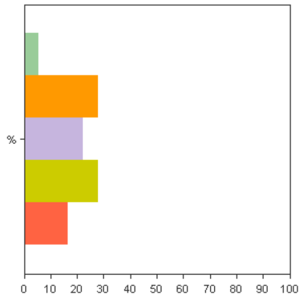


Profile 24

Block: 1

Respondents: 18

Average score: 3.2 ± 1.2

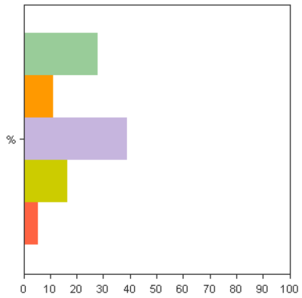


Profile 7

Block: 1

Respondents: 18

Average score: 2.6 ± 1.2

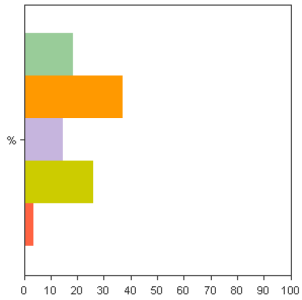


Profile 25

Block: 2

Respondents: 27

Average score: 2.6 ± 1.2

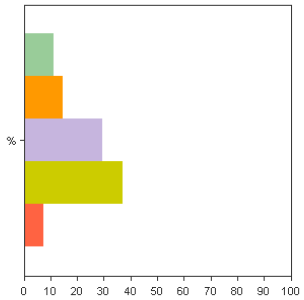


Profile 8

Block: 2

Respondents: 27

Average score: 3.1 ± 1.1

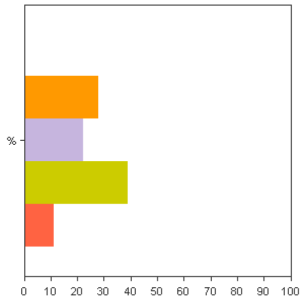


Profile 26

Block: 1

Respondents: 18

Average score: 3.3 ± 1.0

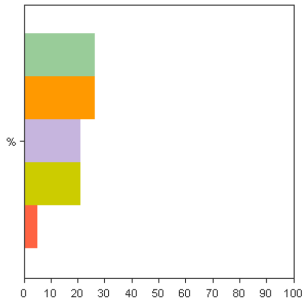


Profile 9

Block: 3

Respondents: 19

Average score: 2.5 ± 1.3

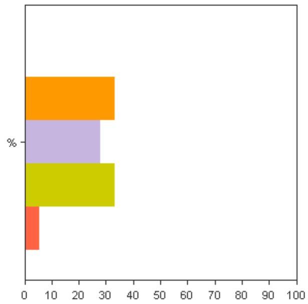


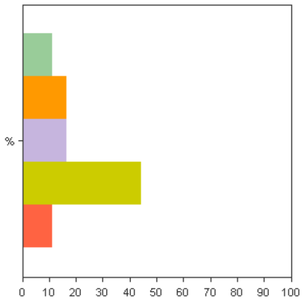
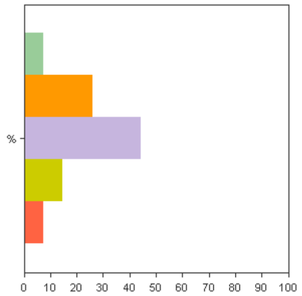
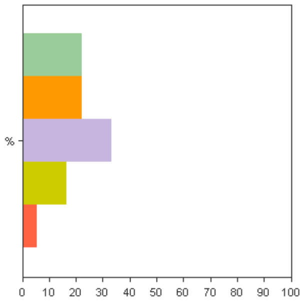
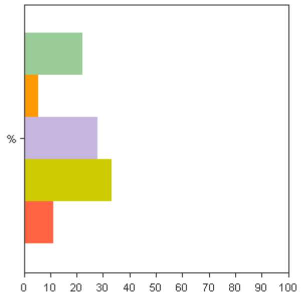
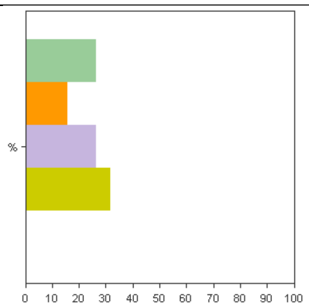
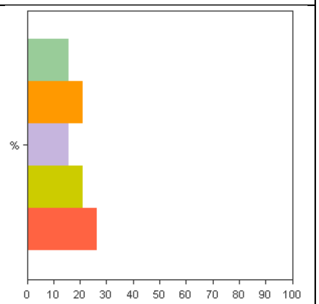
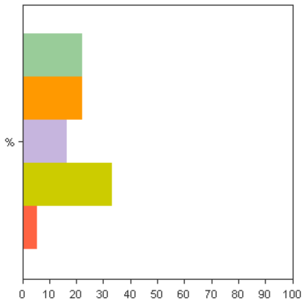
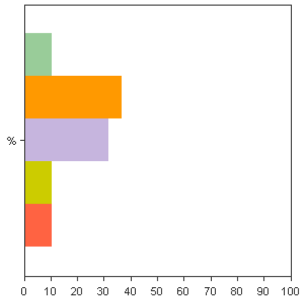
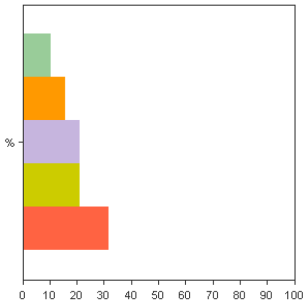
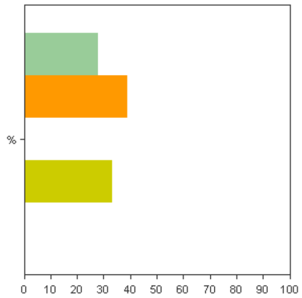
Profile 27

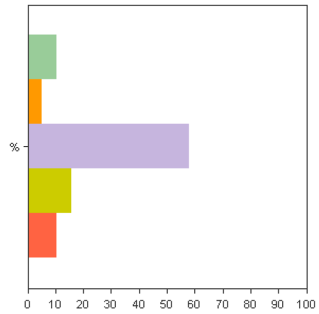
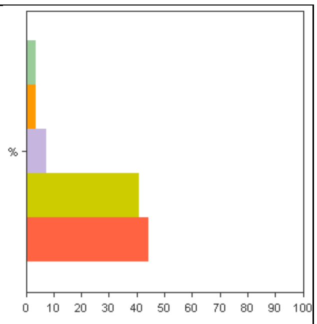
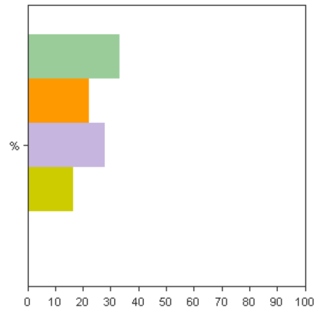
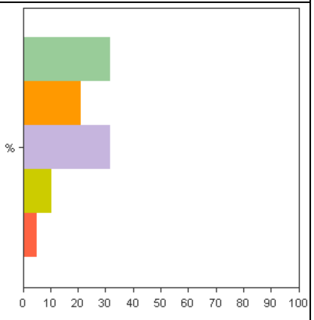
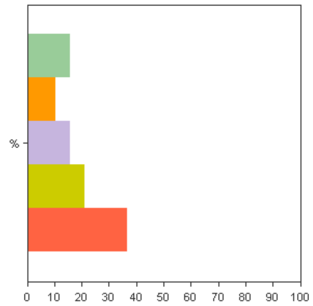
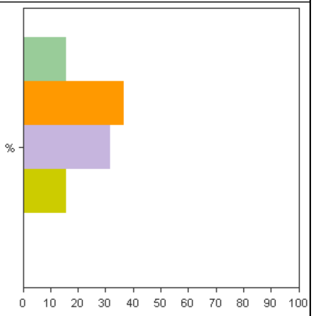
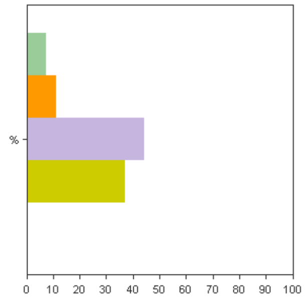
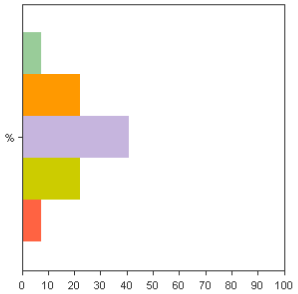
Block: 1

Respondents: 18

Average score: 3.1 ± 1.0



<u>Profile 10</u> Block: 1 Respondents: 18 Average score: 3.3 ± 1.2		<u>Profile 28</u> Block: 2 Respondents: 27 Average score: 2.9 ± 1.0	
<u>Profile 11</u> Block: 1 Respondents: 18 Average score: 2.6 ± 1.2		<u>Profile 29</u> Block: 1 Respondents: 18 Average score: 3.1 ± 1.3	
<u>Profile 12</u> Block: 3 Respondents: 19 Average score: 2.6 ± 1.2		<u>Profile 30</u> Block: 3 Respondents: 19 Average score: 3.2 ± 1.5	
<u>Profile 13</u> Block: 1 Respondents: 18 Average score: 2.8 ± 1.3		<u>Profile 31</u> Block: 3 Respondents: 19 Average score: 2.7 ± 1.1	
<u>Profile 14</u> Block: 3 Respondents: 19 Average score: 3.5 ± 1.4		<u>Profile 32</u> Block: 1 Respondents: 18 Average score: 2.4 ± 1.2	

Profile 15 Block: 3 Respondents: 19 Average score: 3.1 ± 1.0		Profile 33 Block: 2 Respondents: 27 Average score: 4.2 ± 1.0	
Profile 16 Block: 1 Respondents: 18 Average score: 2.3 ± 1.1		Profile 34 Block: 3 Respondents: 19 Average score: 2.4 ± 1.2	
Profile 17 Block: 3 Respondents: 19 Average score: 3.5 ± 1.5		Profile 35 Block: 3 Respondents: 19 Average score: 2.5 ± 1.0	
Profile 18 Block: 2 Respondents: 27 Average score: 3.1 ± 0.9		Profile 36 Block: 2 Respondents: 27 Average score: 3.0 ± 1.0	

Appendix H – Data Analysis Syntaxes

H.1. Distributional Fairness Perception Syntaxes in R

H.1.1. Linear Regression Model

```
###-----------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------- Rating Experiment Script ---------------------------------------------###
###--------------------------------------------- Linear Regression Model ---------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------- Useful commands -------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
rm(list = ls()) #Clear Global Environment
cat("\014") #Clear Console

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------------ Data set ------------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
setwd("data path")
database = read.csv("rating_data.csv", header = TRUE)

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Parameters definition ------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
## 1. Define categoral/nominal/ordered attributes ##
database$spatial_distribution_benefits = as.factor(database$spatial_distribution_benefits)
database$mode_distribution_benefits = as.factor(database$mode_distribution_benefits)
database$age_distribution_benefits = as.factor(database$age_distribution_benefits)
database$mode_distribution_costs = as.factor(database$mode_distribution_costs)
database$income_distribution_costs = as.factor(database$income_distribution_costs)
database$mode_distribution_externalities = as.factor(database$mode_distribution_externalities)
database$age_distribution_externalities = as.factor(database$age_distribution_externalities)
database$children = as.factor(database$children)
database$elderly = as.factor(database$elderly)
```

```
## 2. Define reference for dummy coding ##
database$spatial_distribution_benefits = relevel(database$spatial_distribution_benefits, ref=3)
database$mode_distribution_benefits = relevel(database$mode_distribution_benefits, ref=4)
database$age_distribution_benefits = relevel(database$age_distribution_benefits, ref=3)
database$mode_distribution_costs = relevel(database$mode_distribution_costs, ref=2)
database$income_distribution_costs = relevel(database$income_distribution_costs, ref=1)
database$mode_distribution_externalities = relevel(database$mode_distribution_externalities, ref=4)
database$age_distribution_externalities = relevel(database$age_distribution_externalities, ref=3)
database$children = relevel(database$children, ref=1)
database$elderly = relevel(database$elderly, ref=1)

###--------------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------------- Model Estimation ---------------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------###
model=lm(pdf ~ spatial_distribution_benefits + mode_distribution_benefits + age_distribution_benefits +
          mode_distribution_costs + income_distribution_costs +
          mode_distribution_externalities + age_distribution_externalities,
         data = database)
print(summary(model))
```

H.1.2. Linear Regression Model with Sociodemographic variables

```
###--------------------------------------------------------------------------------------------------------------------------###
###---------------------------------------------- Rating Experiment Script ----------------------------------------------###
###---------------------------------------------- Linear Regression Model ----------------------------------------------###
###-------------------------------------------- w/ sociodemographic variables --------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------###

###--------------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------------- Useful commands ---------------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------###
rm(list = ls()) #Clear Global Environment
cat("\014") #Clear Console

###--------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------------- Data set -------------------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------###
setwd("data path")
database = read.csv("rating_data.csv", header = TRUE)
```

```
###--------------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Parameters definition -------------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------------###
## 1. Define categoral/nominal/ordered attributes ##
database$spatial_distribution_benefits = as.factor(database$spatial_distribution_benefits)
database$mode_distribution_benefits = as.factor(database$mode_distribution_benefits)
database$age_distribution_benefits = as.factor(database$age_distribution_benefits)
database$mode_distribution_costs = as.factor(database$mode_distribution_costs)
database$income_distribution_costs = as.factor(database$income_distribution_costs)
database$mode_distribution_externalities = as.factor(database$mode_distribution_externalities)
database$age_distribution_externalities = as.factor(database$age_distribution_externalities)
database$children = as.factor(database$children)
database$elderly = as.factor(database$elderly)
database$car_commuter = as.factor(database$car_commuter)
database$car_ownership = as.factor(database$car_ownership)

## 2. Define reference for dummy coding ##
database$spatial_distribution_benefits = relevel(database$spatial_distribution_benefits, ref=3)
database$mode_distribution_benefits = relevel(database$mode_distribution_benefits, ref=4)
database$age_distribution_benefits = relevel(database$age_distribution_benefits, ref=3)
database$mode_distribution_costs = relevel(database$mode_distribution_costs, ref=2)
database$income_distribution_costs = relevel(database$income_distribution_costs, ref=1)
database$mode_distribution_externalities = relevel(database$mode_distribution_externalities, ref=4)
database$age_distribution_externalities = relevel(database$age_distribution_externalities, ref=3)
database$children = relevel(database$children, ref=1)
database$elderly = relevel(database$elderly, ref=1)
database$car_commuter = relevel(database$car_commuter, ref=1)
database$car_ownership = relevel(database$car_ownership, ref=1)

###--------------------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------------- Model Estimation ---------------------------------------------------###
###--------------------------------------------------------------------------------------------------------------------------------###
model=lm(pdf ~ spatial_distribution_benefits + mode_distribution_benefits + age_distribution_benefits *
        children + mode_distribution_costs + income_distribution_costs + mode_distribution_externalities +
        age_distribution_externalities + mode_distribution_benefits + age_distribution_benefits +
        age_distribution_benefits + age_distribution_benefits + mode_distribution_costs*car_ownership +
        income_distribution_costs*income + age_distribution_externalities * children +
        mode_distribution_externalities*car_commuter, data = database)


print(summary(model))
```

H.2. Road Safety Policy Choice Model Syntaxes in R

H.2.1. MNL Model

```
###----------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------ Discete Choice Modelling script ----------------------------------------###
###-------------------------------- A. MNL - Multinomial Logistic Regression Model -----------------------------###
###----------------------------------------------------------------------------------------------------------------------------###

###----------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Useful commands ---------------------------------------------------###
###----------------------------------------------------------------------------------------------------------------------------###
rm(list = ls()) ## Clear Global Environment
cat("\014") ## Clear Console

###----------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Required Packages ---------------------------------------------------###
###----------------------------------------------------------------------------------------------------------------------------###
library(apollo) ## load apollo package
apollo_initialise() ## initialise the apollo package code

###----------------------------------------------------------------------------------------------------------------------------###
###-------------------------------------------------------- Data set ---------------------------------------------------------###
###----------------------------------------------------------------------------------------------------------------------------###
setwd("data path")
database = read.csv("choice_data_income.csv", header = TRUE) ## data input

###----------------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------- Model Estimation ---------------------------------------------------###
###----------------------------------------------------------------------------------------------------------------------------###
### 1. Model initialization ###
apollo_control = list (
  modelName = "MNL model",
  modelDescr = "MNL model",
  indivID = "id", ## id of participants
  mixing = FALSE ## mixed logit or random distribution parameters
)
apollo_control$panelData = FALSE ## define if there are panel data (TRUE if panel data)
```

```
### 2. Defining model parameters ###
apollo_beta = c(c = 0, b_cost = 0, b_eff = 0, b_tt = 0, b_pdf = 0, asc_opt_out = 0,
                b_context_eff = 0, b_income_cost = 0
                ) ##specify the betas and constants, and their initial values
apollo_fixed = c("asc_opt_out") ##specify constants

### 3. Validation test ###
apollo_inputs = apollo_validateInputs() ##validate if all inputs have been specified correctly

### 4. Define model ###
apollo_probabilities=function(apollo_beta, apollo_inputs, functionality = "estimate") { ##specify the function to estimate propabilities

  apollo_attach(apollo_beta, apollo_inputs) ## attach model inputs
  on.exit(apollo_detach(apollo_beta, apollo_inputs)) ## detach after exit

  P = list() ## Create list of probabilities

  V = list() ## Create list of utility functions
  V [["alt1"]] = c + (b_eff + b_context_eff * context) * eff1 + (b_cost + b_income_cost * income) * cost1 + b_tt * tt1 + b_pdf * pdf1
  V [["alt2"]] = c + (b_eff + b_context_eff * context) * eff2 + (b_cost + b_income_cost * income) * cost2 + b_tt * tt2 + b_pdf * pdf2
  V [["opt_out"]] = asc_opt_out

  mnl_settings = list( ## define settings
    alternatives = c(alt1 = 1, alt2 = 2, opt_out = 3), ## specify alternatives
    avail= 1, ## specify if the alternatives are always present
    choiceVar = choice, ## define the dependent variable
    V = V ## specify the list that includes the utility functions
  )

  P[["model"]] = apollo_mnl(mnl_settings, functionality) ## Calculate probabilities for MNL_model

  P = apollo_prepareProb(P, apollo_inputs, functionality) ## Prepare and return outputs of function

  return(P)
}
```

```
### 5. Model estimation ###
MNL_model = apollo_estimate(apollo_beta, apollo_fixed, apollo_probabilities, apollo_inputs)

### 6. Present Model outputs ###
modelOutput_settings = list()
modelOutput_settings$printPVal=TRUE
apollo_modelOutput(MNL_model,modelOutput_settings)
apollo_saveOutput(MNL_model)
```

H.2.2. Panel effect Mixed Logit Model

```
###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------ Discrete Choice Modelling script ----------------------------------------###
###--------------------------------------------- B. Panel Mixed Logit (ML) -------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Useful commands ------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
rm(list = ls()) ## Clear Global Environment
cat("\014") ## Clear Console

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------ Required Packages ------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
library(apollo) ## load apollo package
apollo_initialise() ## initialise the apollo package code

###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------------------ Data set ------------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
setwd("data path")
database = read.csv("choice_data_income.csv", header = TRUE) ## data input
```

```
###---------------------------------------------------------------------------------------------------------------------------###
###-------------------------------------------------- Model Estimation --------------------------------------------------###
###---------------------------------------------------------------------------------------------------------------------------###
### 1. Model initialization ###
apollo_control = list (
  modelName = "ML model",
  modelDescr = "ML model",
  indivID = "id", ## id of participants
  mixing = TRUE ## mixed logit or random distribution parameters
)

### 2. Defining model parameters ###
apollo_beta = c(asc_opt_out = 0, c = 0,
                b_cost = 0, b_eff=0, b_pdf = 0, b_tt = 0,
                b_income_cost = 0,
                b_context_eff = 0,
                sigma_pdf = 1, sigma_cost = 1, sigma_eff = 1
) ##specify the betas and constants, and their initial values
apollo_fixed = c("asc_opt_out") ##specify constants

### 3. Define draws ###
apollo_draws = list(
  interDrawsType = "halton",
  interNDraws = 250,
  interUnifDraws = c(),
  interNormDraws = c("draws_c","draws_pdf", "draws_cost", "draws_eff"),
  intraDrawsType = "halton",
  intraNDraws = 0,
  intraUnifDraws = c(),
  intraNormDraws = c()
)

### 4. define random parameters ###
apollo_randCoeff = function(apollo_beta, apollo_inputs){
  randcoeff = list()
  randcoeff[["cost_panel"]] = b_cost + sigma_cost *draws_cost
  randcoeff[["eff_panel"]] = b_eff + sigma_eff *draws_eff
  randcoeff[["pdf_panel"]] = b_pdf + sigma_pdf *draws_pdf
  return(randcoeff)
}
```

```
### 5. Validation test ###
apollo_inputs = apollo_validateInputs() ##validate if all inputs have been specified correctly


### 6. Define model ###
apollo_probabilities=function(apollo_beta, apollo_inputs, functionality = "estimate") { ##specify the function to estimate propabilities


  apollo_attach(apollo_beta, apollo_inputs) ## attach model inputs
  on.exit (apollo_detach(apollo_beta, apollo_inputs)) ## detach after exit


  P = list() ## Create list of probabilities


  V = list() ## Create list of utility functions
  V [["alt1"]] = c + (eff_panel + b_context_eff * context) * eff1 + (cost_panel + b_income_cost * income) * cost1 + b_tt * tt1 + pdf_panel * pdf1
  V [["alt2"]] = c + (eff_panel + b_context_eff * context) * eff2 + (cost_panel + b_income_cost * income) * cost2 + b_tt * tt2 + pdf_panel * pdf2
  V [["opt_out"]] = asc_opt_out


  mnl_settings = list( ## define settings
    alternatives = c(alt1 = 1, alt2 = 2, opt_out = 3), ## specify alternatives
    avail= 1, ## specify if the alternatives are always present
    choiceVar = choice, ## define the dependent variable
    V = V ## specify the list that includes the utility functions
  )


  P[["model"]] = apollo_mnl(mnl_settings, functionality) ## Calculate probabilities for MNL_model


  P = apollo_panelProd(P, apollo_inputs, functionality) ## Take product across obserbation for the same individual, to be used for panel data


  P = apollo_avgInterDraws(P, apollo_inputs, functionality) ## Average across inter-individual draws


  P = apollo_prepareProb(P, apollo_inputs, functionality) ## Prepare and return outputs of function
  return(P)
}
```

```
### 7. Model estimation ###
ML_model = apollo_estimate(apollo_beta, apollo_fixed, apollo_probabilities, apollo_inputs, estimate_settings=list(hessianRoutine="maxLik"))


### 8. Present Model outputs ###
modelOutput_settings = list()
modelOutput_settings$printPVal=TRUE
apollo_modelOutput(ML_model,modelOutput_settings)
apollo_saveOutput(ML_model)
```

H.2.3. Panel effect Mixed Logit Model with Interaction Effects

```
###-----------------------------------------------------------------------------------------------------------------------###
###------------------------------------------- Discrete Choice Modelling script -------------------------------------------###
###---------------------------------- C. Panel Mixed Logit (ML) with interaction effects -------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###


###-----------------------------------------------------------------------------------------------------------------------###
###-------------------------------------------------- Useful commands -------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
rm(list = ls()) ## Clear Global Environment
cat("\014") ## Clear Console


###-----------------------------------------------------------------------------------------------------------------------###
###-------------------------------------------------- Required Packages ----------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
library(apollo) ## load apollo package
apollo_initialise() ## initialise the apollo package code


###-----------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------------------- Data set ---------------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
setwd("data path")
database = read.csv("choice_data_income.csv", header = TRUE) ## data input


###-----------------------------------------------------------------------------------------------------------------------###
###--------------------------------------------------- Model Estimation ---------------------------------------------------###
###-----------------------------------------------------------------------------------------------------------------------###
```

```
### 1. Model initialization ###
apollo_control = list (
  modelName = "ML model with interaction effects",
  modelDescr = "ML model with interaction effects",
  indivID = "id", ## id of participants
  mixing = TRUE ## mixed logit or random distribution parameters
)

apollo_control$panelData = TRUE ## define if there are panel data (TRUE if panel data)

### 2. Defining model parameters ###
apollo_beta = c(asc_opt_out = 0, c = 0,
                b_cost = 0, b_eff=0, b_tt = 0, b_pdf = 0,
                b_context_eff = 0, b_cost_income = 0,
                sigma_cost = 1, sigma_eff = 1, sigma_pdf = 1,
                b_cost_pdf = 0, b_tt_pdf=0, b_eff_pdf = 0
) ##specify the betas and constants, and their initial values
apollo_fixed = c("asc_opt_out") ##specify constants

### 3.1. Define draws ###
apollo_draws = list(
  interDrawsType = "halton",
  interNDraws = 250,
  interUnifDraws = c(),
  interNormDraws = c("draws_pdf", "draws_cost", "draws_eff"),
  intraDrawsType = "halton",
  intraNDraws = 0,
  intraUnifDraws = c(),
  intraNormDraws = c()
)

### 3.2. define random parameters ###
apollo_randCoeff = function(apollo_beta, apollo_inputs){
  randcoeff = list()
  randcoeff[["cost_panel"]] = b_cost + sigma_cost *draws_cost
  randcoeff[["eff_panel"]] = b_eff + sigma_eff *draws_eff
  randcoeff[["pdf_panel"]] = b_pdf + sigma_pdf *draws_pdf
  return(randcoeff)
}
```

```
### 4. Validation test ###
apollo_inputs = apollo_validateInputs() ##validate if all inputs have been specified correctly


### 5. Define model ###
apollo_probabilities = function(apollo_beta, apollo_inputs, functionality = "estimate") { ##specify the function to estimate propabilities


  apollo_attach(apollo_beta, apollo_inputs) ## attach model inputs
  on.exit (apollo_detach(apollo_beta, apollo_inputs)) ## detach after exit


  P = list() ## Create list of probabilities


  V = list() ## Create list of utility functions with interactions
  V [["alt1"]] = c + (eff_panel + b_context_eff * context + b_eff_pdf * pdf1) * eff1 +
   (cost_panel + b_cost_income * income) * cost1 + b_cost_pdf * cost1 * pdf1 +
   b_tt * tt1 + b_tt_pdf * tt1 * pdf1 +
   pdf_panel * pdf1
  V [["alt2"]] = c + (eff_panel + b_context_eff * context + b_eff_pdf * pdf2) * eff2 +
    (cost_panel + b_cost_income * income) * cost2 + b_cost_pdf * cost2 * pdf2 +
   b_tt * tt2 + b_tt_pdf * tt2 * pdf2 +
   pdf_panel * pdf2
  V [["opt_out"]] = asc_opt_out


  mnl_settings = list(  ## define settings
    alternatives = c(alt1 = 1, alt2 = 2, opt_out = 3), ## specify alternatives
    avail= 1, ## specify if the alternatives are always present
    choiceVar = choice, ## define the dependent variable
    V = V ## specify the list that includes the utility functions
  )


  P[["model"]] = apollo_mnl(mnl_settings, functionality) ## Calculate probabilities for MNL_model


  P = apollo_panelProd(P, apollo_inputs, functionality) ## Take product across obserbation for the same individual, to be used for panel data


  P = apollo_avgInterDraws(P, apollo_inputs, functionality) ## Average across inter-individual draws


  P = apollo_prepareProb(P, apollo_inputs, functionality) ## Prepare and return outputs of function
  return(P)
}
```

```
### 6. Model estimation ###
ML_model = apollo_estimate(apollo_beta, apollo_fixed, apollo_probabilities, apollo_inputs, estimate_settings = list(hessianRoutine = "maxLik"))


### 7. Present Model outputs ###
modelOutput_settings = list()
modelOutput_settings$printPVal=TRUE
apollo_modelOutput(ML_model,modelOutput_settings)
apollo_saveOutput(ML_model)
```