

Value of travel time in SCBA

[Exploring the best use of the value of travel time
into social cost benefit analyses]

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PREFACE

This report is written in the context of my master thesis within the master “Construction, Management and Engineering” at the Technical University Delft. This report was realized in corporation with Witteveen+Bos.

Using this preface, I would like to thank everyone who has contributed to the realization of this master thesis. Primarily I would like to thanks my thesis committee: Prof.dr.ir. M.J.C.M. Hertogh, Dr. ir. R.J. Verhaeghe and Dr. JA. Annema for their help and feedback on my master thesis. I would also like to thank Drs. A.J. Gijsman and J. Brouwer from Witteveen+Bos for making this master thesis possible. Further I want to thank the employees of Witteveen+Bos and Bruins & Kwast for participating in the stated preference experiment.

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Jeroen Kwast

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SUMMARY

The reduction of the travel time on the main road network was the last decade an important issue for the Dutch government. Within line infrastructure projects are the travel time benefits the most important benefits post in a social cost benefit analyses. Experts and users of social cost benefit analyses, complained that travel time benefits could be better implemented in social cost benefit analyses. The experts and users have two discussion topics: the determination of these travel time benefits and the use of these benefits in social cost benefit analyses. Therefore is the main objective of this report:

Give a recommendation on the use of the value of travel time in social cost benefit analyses

The report is divided into five phases. In each phase a (sub) objective will be reached using research questions. The first phase (phase A) will start with the first sub objective and the last phase (phase E) will conclude with the main objective.

PHASE A: CALCULATION OF THE TRAVEL TIME SAVING BENEFITS IN THE NETHERLANDS

To gain insight into the way of using travel time savings in The Netherlands, is the following research question drawn:

“What are the possible improvements in the current Dutch value of travel time determination and in the use of value of travel time in social cost benefit analyses?”.

To answer that question an complete analysis of the Dutch value of travel time study of 1998 and an analysis of the Dutch value of travel time study of 2013 have been made. The Dutch value of travel time study of 2013 is used to describe the differences between the 1998 and 2013 studies.

After analysing these Dutch value of time studies three subjects were marked as possible improvements. The three subjects are:

- Small vs. bigger time savings;
- Time gains and losses;
- Income.

These three subjects were marked, because determination of the travel time benefits did not match with the data from the value of time studies The travel time benefits are calculated with a constant unit value of travel time. While the results of the stated preference experiments (used for the estimation of the value of travel time) shows that the valuation per minute decreases if the amount of saved travel time decrease. Also it shows that the value of travel time increases if the average household income increase. Finally the results show that willingness to pay for time savings is lower than the willingness to accept for time losses. Despite these findings the travel time benefits are calculated using a constant unit value, which is independent on the size and sign of the amount of time change. In addition the income dependent value of travel time key-figures are not used for the calculation of the travel time benefits. These three points will therefore be taken to the next phase.

PHASE B: REVIEW ON THE THREE POSSIBLE IMPROVEMENTS

Knowing that there are three possible improvements, the following question is central:

“What does other literature tell about the feasibility of these possible improvements?”

To research the feasibility of these possible improvements foreign value of travel time studies plus general literature on these subjects has been reviewed. In total six foreign value of travel time studies have been used for this review. The six foreign value of travel time studies that have been used are from the following countries: Denmark, Norway, United Kingdom, Sweden, Switzerland and the United States. The general literature varied per subject.

Small time savings: Discussion on the valuation of small time savings is ongoing. All the foreign value of travel time studies suggest the use of a constant unit value. Even though all the value of travel time studies (that used a stated preference experiment) founded a lower valuation for smaller time savings than for normal time savings. In addition almost all studies suggested that further research on this subject is needed. In contrast, some countries used a different method to determine the travel time benefits for small time savings.

During the review of the general literature it became clear that some reports are in favour of a lower value of travel time for small time savings, others rejected these ideas.

The reports that are in favour and some foreign value of travel time studies provide some idea's and thoughts why the current stated preference experiments are not suitable for the valuation of small time savings. These points give some insights on which the stated preference design can be improved so it is better suitable for the determination of the value of small time savings. Therefore is this subject further explored in this report.

Time savings and losses: At this point literature is more straightforward. All the foreign value of travel time studies reject a difference in valuation between time savings and losses. They also state that further research on this subject is unnecessary. However, some results of value of travel time studies which used stated preference experiments showed a different valuation between losses and savings. This effect can be explained by economic effect of loss aversion. The value of travel time studies reject this effect, because on the long term it would disappear or because people are more likely to choose for the reference alternative in SP surveys.

In addition general literature is not in favour for a different valuation of time savings and losses. One study showed that the difference in willingness to pay and willingness to accept using a revealed preference study was significant lower than using a stated preference experiment. Also the literature suggested that this effect must be measured using revealed preference analysis. For this master thesis it was not possible to exam a revealed preference study, so therefore this point is not further explored in this report.

Income dependent value of travel time: At this point most of the foreign value of travel time studies reject a income dependent value of travel time, despite the fact that they all find a relation between the monthly income and the value of travel time. Some of the reports state that the income dependency is already adopted into the different categories of travel purposes and modes. Others state that huge infrastructure projects affect all income groups and therefore an average value of travel time can be used.

For a more accurate use of income dependent value of travel time in social cost benefit analyses, the value of travel time should be dependent on the income, on the travel purpose and on the travel mode. A complex questionnaire is necessary to draw significant conclusions. A disadvantage of very big questionnaires is that the reliability of the output is lower. In order to compensate for that effect a very large sample is needed. This was not achievable, therefore this point is not further explored in this report.

The conclusion of this phase is that the subject of 'small time savings' is the only feasible subject to investigate during this master thesis. Therefore shall this subject be taken to the next phase.

PHASE C: DETERMINE THE VALUE OF TRAVEL TIME OF SMALL TIME SAVINGS

In third phase a research has been done concerning the valuation of small time savings. Based on the recommendations of the literature review, there is a stated preference experiment designed. The most

important recommendations in comparison to the current design of the stated preference experiment used in the Dutch value of travel time study were:

- Using respondents with short distance travels;
- Using smaller time constraints in the stated preference experiment;
- Using stated preference questions which not reflecting to a unique reference trip.

The stated preference experiment is presented to a group of 841 respondents. These respondents are recruited within the company Witteveen+Bos. A disadvantage of this sample is that it is not a perfect reflection of the Dutch society. The respondents are on average higher educated and have on average an higher monthly income.

After analysing the data of the respondents 59 useful complete questionnaires remain. With these useful questionnaires an estimation of the value of travel time for small time savings is made. The estimation model is based on the multinomial non logit model. The outcomes of the model shows a significant lower value of travel time for small time savings than the current Dutch value of travel time key-figures, namely:

	Value of travel time per minute	Value of travel time per hour
Small time savings	€0,06	€3,76
Normal	€0,15	€9,71

Another outcome of the stated preference analyse is that, 75 per cent of the respondents state that the time threshold of small time savings should be set between 5 and 10 minutes. This is in line with the literature reviewed in the previous phase.

Because of the relatively small sample size, the results should be interpreted with caution. Furthermore, the respondents were on average better educated and have on average a higher monthly income, compared to the general Dutch population. Nevertheless the research indicates that there is a trend that small time savings are lower valued. Especially because in general people with higher incomes value travel time higher.

The results of this chapter will be taken to the next phase.

PHASE D: CASE STUDY

The effects of these new value of travel time figures are measured during a case study. The case is an existing Dutch medium size road project, whereby the data of the traffic model is split into different categories of time saving. Due this disaggregated traffic model it is possible to implement the new value of travel time key-figures into the travel time saving benefit calculation. For the calculation of the travel time benefits three different models were used:

- Constant value of travel time: In this method there is no distinction between small and normal travel time savings, all time savings benefits are calculated with the same value of travel time;
- Step function: In this method the small time savings are valued with a lower value of travel time than the normal time savings;
- General Linear Discounting function: In this method the valuation of small time savings is growing linearly with the time saved. After a certain time threshold a normal value of travel time is used.

The results show that the benefits using the step methods lies on 60 per cent of the constant value of travel time method. In the General Linear Discounting function the VoTT per minute grows until z^* is reached. When using this method the travel time benefits for this case project will decrease with 20 per cent.

PHASE E: RECOMMENDATIONS & CONCLUSIONS

Because 'small time savings' was the only subject completely reviewed is the main conclusion: There is reason to believe that small time saving benefits shall be calculated otherwise in social cost benefit analyses. However, this cannot be concluded from this study. Therefore more research on this subject is required.

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ABBREVIATIONS

AVV	Adviesdienst Verkeer en Vervoer
CBS	Centraal Bureau voor de Statistiek
CUV	Constant Unit Value
DUV	Derivative Unit Value
DVS	Dienst Verkeer en Scheepsvaart
EIA	Environmental Impact Assessment
GLD	General Linear Discounting function
LMS	Landelijk Model Systeem
Notitie R&D	Notitie Reikwijdte en Detail niveau
NRM	Nieuw Regionaal Model
OEEI	Onderzoeksprogramma Economische Effecten Infrastructuur
OEI	Overzicht Effecten Infrastructuur
RAV	Reduced Average Value
RP	Revealed Preference
RWS	Rijkswaterstaat
SC	Stated Choice
SCBA	Social Cost Benefit Analyses
SP	Stated Preference
UK	United Kingdom
US	United States
VoTT	Value of Travel Time
W+B	Witteveen+Bos
WTP	Willingness to pay
WTA	Willingness to accept

1 INTRODUCTION

This chapter will explain the motive, goal and process of the research and has the following structure: In the first paragraph the motivation for this research will be described and in the second paragraph the research problem will be defined. From this research problem three research objectives are derived in the third paragraph. In the same paragraph the relevance of this research is mentioned. In the fourth paragraph the research questions are described to reach the research objectives. The fifth paragraph describes the approach which will be used to answer these research questions. In the final paragraph of this chapter a preview of the report structure will be defined.

1.1 WHY THIS RESEARCH?

In the past decade 2000 - 2010 the Dutch national government spent a great deal of attention to the reduction of travel time on the main road network. Some examples of projects which have been build or planned in the past years will illustrate this. The first example is the approach of thirty bottlenecks on the national motorway network. The former minister of Infrastructure and Environment gave the starting shot for the solution of these bottlenecks in October 2008. In most cases additional (rush-hour)lanes were constructed to improve the traffic flow at these bottlenecks on the Dutch national motorway network. The total costs for all the improvements of these bottlenecks where estimated on 2.6 milliard euro (Schultz van Haegen, 2011). Another example to decrease the travel time is the decision to increase the maximum speed limit on the national motorway network. The speed limit on some roads increased from 80 km/h to 100 km/h and on some other roads the speed limit is increased from 120 km/h to 130 km/h. The expected travel time gain resulting from the increased speed limit is estimated to be one per cent of the total journey time on the motorway network (Rijkswaterstaat, 2011). Against these time gains are the costs for the implementation of the increased speed limit. These costs are estimated at 6 million euro (Ministerie van Infrastructuur en Milieu, 2011). Besides these two examples a lot more projects are build or planned to decrease the travel time on the national motorway network.

Travel time savings are often one of the most important objectives with investments in transport infrastructure projects, like roads, railways and waterways. This is not only the case by investments made by the national government, but also with investments made by lower governmental scales like the provinces and municipalities.

For almost all the infrastructure projects since 2000, which are financed by the Dutch national government, a Social Cost Benefit Analyses (SCBA) is used to see whether a project is economic feasible or not. In the SCBA a review of all the expected effects of the planned infrastructure are systematic displayed in terms of money. By reviewing the costs and all the expected effects in terms of money it is possible to analyse whether or not a project is economic feasible. The biggest benefit in transport infrastructure is, in almost every case, generated by the travel time savings (Donkelaar & Mulder, 2011). Sometimes this is even the case when the travel time savings are relatively small, like the second example project where the speed limit was increased on the Dutch national motorways. In that specific project the estimated benefits of the reduced travel time are the only positive benefits and the project was still economically feasible (Rijkswaterstaat, 2011).

For these kinds of projects it might be wise to critical review the methods used for the determination of the travel time benefits.

1.2 PROBLEM DEFINITION

The need to review the travel time benefits is already mentioned in the previous paragraph. But besides the general need for a review on the travel time benefits, there are some users and experts who describe some more specific critical points of the travel time benefits and the methods used to imply the travel time benefits

in the SCBA. For this problem definition three examples of critical points, mentioned by users and experts, will be described.

The first example comes from a study of Mouter et al. (2012). In that study Mouter et al. have analysed the SCBA by interviewing 86 key players (policy makers, scientists and consultancies) in the Dutch SCBA. In this study is mentioned by two respondents that the interpretation of value of travel time (VoTT) for small time changes in SCBA could be performed more precisely (Mouter, Annema, & van Wee, 2012). The VoTT is the travellers willingness to pay for a reduction of travel time. In many studies for the determination of the VoTT is found that the VoTT per minute grows when the time changes increases (Hjorth & Fosgerau, 2012). Despite this conclusion a constant VoTT time is used for small travel time savings in most of the European countries, including The Netherlands. According to the two respondents a lower unit of VoTT should be used by smaller travel time savings.

The second example is the critical point described by Van Holst (2010). He has his doubts about the general use of SCBA. The SCBA for big infrastructure projects is positively evaluated in the evaluation OEEI¹ guidance (BCI, 2002). But despite this good evaluation Van Holst complains in his article in the magazine 'economists in debate' on the use of the SCBA (van Holst, 2010). His complain is mainly on the opinion that the SCBA is becoming a blanks exercise. Nowadays during project evaluations the tables are only filled in according to the general work guides and key-figures (Rienstra & Visser, 2010), instead of looking to the location of the project. By executing a SCBA according to these general work guides and key-figures a fifteen minutes travel time saving in a shrinking area is appreciated the same as a fifteen minutes travel time saving in the Randstad², while the expected effects for the economy as a result of the travel time savings is higher in the economic stronger region the Randstad as in the economic shrinking area.

The final example is that the total travel time of the traveller is not taken into account by the implementation of VoTT in SCBA. A consequence hereof is that a decrease of one minute by a total travel time of one and a half hour is as highly valuated as one minute by a total travel time of ten minutes. This means that for this example a decrease in travel time of 10 percent travel time is as highly valuated as a decrease in travel time of one percent. Beside this point the VoTT per minute is the same for a decreasing- and increasing total travel time, while a research in 2008 has demonstrated that travel time loss is higher valued as travel time gains. Travel time losses are valued twice as high compared to travel time savings by travellers with variable arrival working times. Travel time losses are even three times more valued by travellers with fixed working times (Asensio & Matas, 2012).

The three critical examples mentioned above give a reason for a discussion about the determination of VoTT and about the use of VoTT in SCBA. Besides the three examples some other examples may rise during the research of this report. These points of criticism combined with the fact that the VoTT is used for the most important benefit gives enough reasons to reinvestigate the determination of VoTT and the use of VoTT in SCBA.

1.3 RESEARCH OBJECTIVES AND RELEVANCE

The main goal of this research is:

Give a recommendation on the use of the VoTT in SCBA.

¹ OEEI stands for Onderzoeksprogramma Economische Effecten Infrastructuur (EN: research program on economic effects of infrastructure)

² Randstad is a metropolitan region which includes the cities of Amsterdam, Rotterdam, The Hague and Utrecht.

To reach this main goal first four other 'sub' objectives should be completed:

- Give a review of the current Dutch use of VoTT in SCBA and give an indication of the possible improvements;
- Indicate whether or not the possible improvements are feasible, by reviewing foreign VoTT studies and general literature;
- Design alternatives for these possible improvements;
- Give a review on the effects of these possible alternatives;

As mentioned in paragraph 1.1, travel time benefits are in most cases the biggest part of the total benefits in a SCBA. Therefore a small change in the travel time benefit post can directly influence the outcome of the SCBA. This changing outcome of the SCBA on its turn has influence on the decision making process. So the results of this research can have influence on the travel time benefits and the total decision making process.

1.4 RESEARCH QUESTIONS

To achieve the objectives, as described above, research questions must be compiled. The main research question shall answer the main objective:

What is, for car drivers, the recommended method to assess the travel time savings in SCBA?

To get all the input which is necessary to answer the main research question some sub questions are defined. The sub questions are related to the three sub objectives given in paragraph 1.3.

- What are the possible improvements in the current Dutch VoTT determination and in the use of VoTT in SCBA?
 - How is, in The Netherlands, the VoTT currently determined?
 - How is the travel time benefit currently determined in a SCBA?
 - Where are opportunities for improvement?
- What does other literature tell about the feasibility of these possible improvements?
 - How is the VoTT determined and used in SCBA in other countries?
 - What does general literature say about these possible improvements?
 - Considering the answers on two questions above, are the possible improvements feasible?
- What could be possible alternatives for the feasible possible improvements?
 - What is needed for the alternatives?
 - How can the alternatives be implemented in an SCBA?
- What are the effects of these possible alternatives in a SCBA?
 - What are the effects of the possible alternatives on the input which is needed for a SCBA?
 - What are the effects of the possible alternatives on the outcomes of an SCBA?

1.5 APPROACH

1.5.1 SCOPE

During this research the focus will be on the VoTT of private passenger transport (car drivers), for the travel purpose commute. The aspects of public transport shall not be researched.

Since a new report on the Dutch value of travel time key-figures is released in summer of 2013, this report will not supply new key-figures for the standard VoTT. However a research to the VoTT by time savings smaller than

5 minutes will be performed because the current and new Dutch research (Hague Consulting Group, 1998) do not pay attention to travel time savings smaller than 5 minutes.

1.5.2 WAY OF APPROACH

The research is divided into five phases. During the first four phases the sub questions will be examined and these four phases together will provide the information needed to answer in the fifth phase the main research question. The four research objectives are also attached to the first four phases. In figure 1 the research process is shown schematically. In the text after the figure the four phases will be described in more detail.

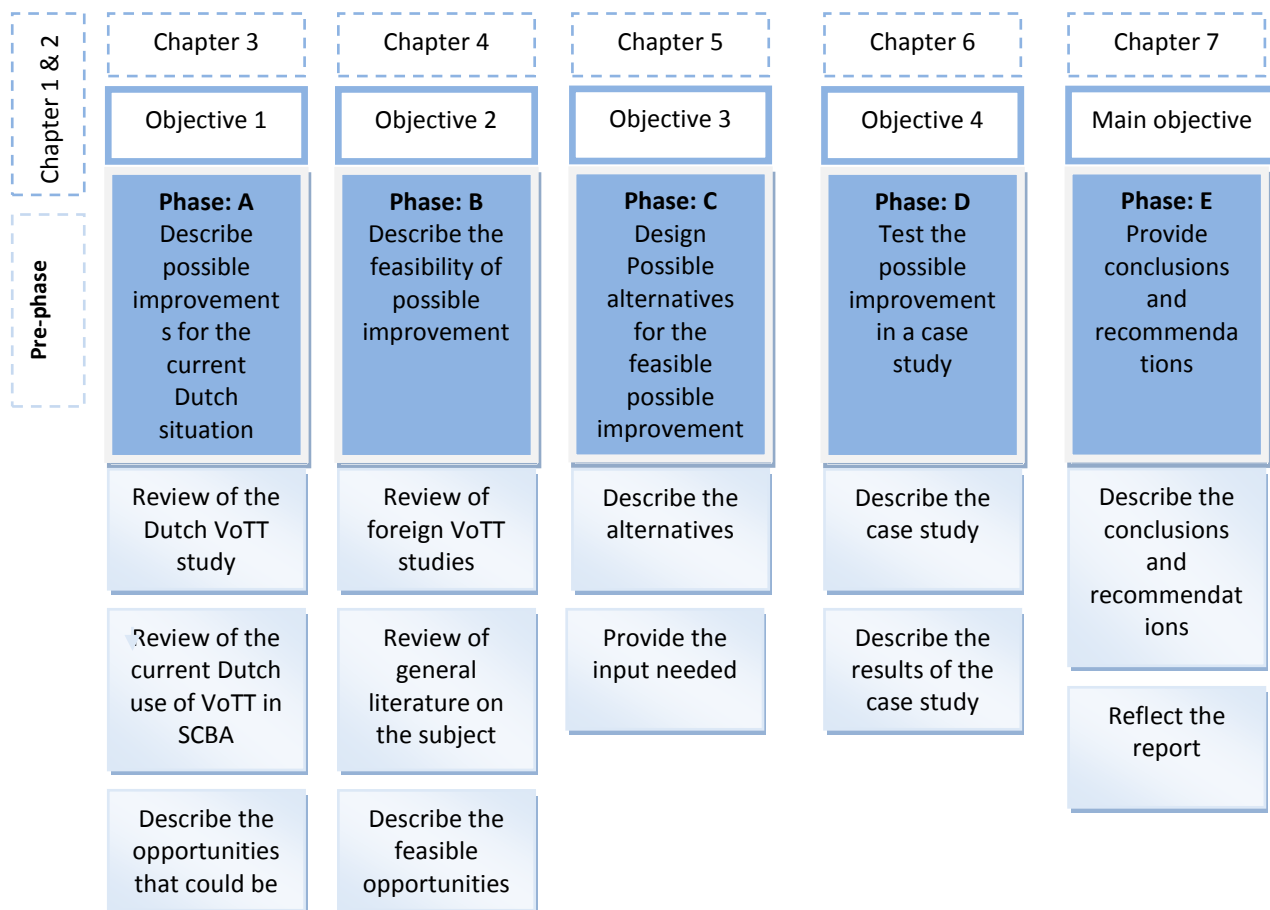


FIGURE 1, RESEARCH SCHEDULE

PHASE A:

In this first phase a review will be made of the current Dutch use of VoTT in SCBA and this will be done by a literature study. A number of experts have been interviewed to point some directions which would be interesting to investigate and provide some literature. These interviews were only used to give some indications; therefore no direct references to the interviewees are made. A list of the experts who are contacted can be found in appendix I. In the review of the current situation the arguments, the necessary input and advantages/disadvantages for the chosen methods are of great importance. This information is needed in the research of alternatives. After reviewing the current situation several opportunities for improvement are described. These opportunities for improvement are the basis for phase B.

PHASE B

In the second phase the feasibility of the possible improvements will be researched. To do so a review is made of foreign VoTT researches and general literature regarding the possible improvements. So for phase B the research method will be a literature research again. Some alternatives for the possible improvements will be found thanks to the review of the literature. For these alternatives it is very important to understand the input

needed, arguments for or against and the advantages or disadvantages. It can be possible that alternatives will be found which need more research than currently is generated in The Netherlands. When all the information is reviewed the feasible opportunities for improvement will be the basis for phase C.

PHASE C

During the third phase, solutions will be defined for the possible improvements. Information gathered in phase A and B will be used for the development of the alternatives. During this phase some extra research is needed to give an indication concerning the VoTT for small time savings. This will be examined using a survey research. This phase concludes with a recommendation of turnkey solutions which can be applied in SCBA.

PHASE D

When the solutions are completely developed, these will be compared to the current methods to see the effects on the input and outcomes of the SCBA. The reason why this report focuses not only on the effects of the output, is because there is a possibility that the outcomes show small advantages, but that there is much more input needed which create a big disadvantage. To test the different methods, an old SCBA project and attached input will be used for the case study. The projects will be real but anonymous. The outcomes of the effects will be used as input in the last phase.

PHASE E

In the last phase the outcomes of the case studies done in phase C will be evaluated. A recommended method will be described in this evaluation. The best method depends on theoretical- and practical aspects. After the evaluation conclusions can be made, which will lead to an advice on the best use of VoTT in SCBA. With that advice the main research question will be answered.

1.6 PREVIEW

In each of the first four phases one sub question will be answered, which results in completing the sub objectives. In the final phase the information of the first four phases is used to answer and complete the main research question and objective. The report is structured in the following way:

In the next chapter, chapter 2, a general background for the understanding of this research will be described. In chapter 3 the first phase, phase A, will be described. Phase A concludes with the finding of three possible main improvements. The results of this chapter will then be taken to phase B which is described in chapter 4. This chapter concludes whether or not these possible improvements are feasible for further research. An alternative for feasible possible improvements is research in phase C, described in chapter 5. When the alternatives are complete they will be tested during a case study in phase D, described in chapter 6. Finally in phase E, chapter 7, the main research question is answered.

2 BACKGROUND INFORMATION

This chapter will present a theoretical background to get a better understanding of the research. This chapter will explain the notions mentioned in chapter one and other notions.

This chapter uses the following sequence. First “Social Cost Benefit Analyses” is described and explained, then the input needed for the calculation of travel time saving benefits will be described

2.1 SOCIAL COST BENEFIT ANALYSES (SCBA)

The goal of the SCBA is to compare project alternatives on the basis of the impact these projects have on welfare of society, so the social costs and benefits (Faber, Mulders, Politiek, & Ministerie van EZ, 2012). The SCBA gives answers to the following questions:

- What are the costs and social benefits of the project alternatives? and;
- Who bears the costs and who enjoys the benefits?

The SCBA is an analysis for projects whereby all the social relevant effects of a project are schematically described. Hereby the different effects should be expressed in terms of money as much as possible. The costs and benefits can be determined for all the effects which can be expressed in terms of money. For the effects like environment and safety it is not directly possible to express the value in terms of money. These effects must be inventoried which is sometimes difficult, but the development of techniques and methods to make this possible are still developing. Often these effects are inventoried using opportunity costs. The opportunity cost of a choice is the value of the best alternative forgone, in a situation in which a choice needs to be made between several alternatives given limited resources (Verhaeghe, 2012). Effects that are not possible to express in terms of money must also be described in the SCBA, because the SCBA describes all the effects that people experience as useful and useless.

There are three sorts of effects described in the SCBA, namely: direct effects, indirect effects and external effects (Faber, Mulders, Politiek, & Ministerie van EZ, 2012). Explanations of these effects are:

- Direct effects: Effects for actors in the market where the project directly engages on. An example of a direct effect for a road construction is the benefit of travel time savings;
- Indirect effects: Effects for actors in market other than where the project is primarily aimed on. An example of an indirect effect for a road construction could be that because a shorter travel time, multiple supermarkets come into travel range which results in more competition and finally in lower prices. The indirect effects are often calculated by multiplying the direct effect times with a ratio for the indirect effect. Another method for the determination of the indirect effects is by using models like RAEM-2;
- External effects: Effects outside the market which end up with stakeholders. An example of an external effect for a road construction is noise pollution from additional traffic.

The SCBA gives information of the financial consequences from the different project alternatives, by expressing the effects of the project alternatives in terms of money. Therefore policy makers and other stakeholders have access to more and better information to compare the different alternatives, which results in a better decision making. In The Netherlands the SCBA is used as additional information to support the decision, but is not decisive for the decision. In The Netherlands the decision always is done by the policy makers who use information like the SCBA for their decision making (Faber, Mulders, Politiek, & Ministerie van EZ, 2012). This means that policy makers can decide that the project must be build even when the SCBA for that project is negative. The SCBA supplies the following information which can support the decision making:

- Different project alternatives;
- The relation between the measures and the effects;
- The risks and uncertainties of the measures;
- Distribution of the costs and benefits;
- An integral social consideration of the different effects.

The above summarised information is often used as a supporting tool during the decision making process of large infrastructure projects. The input of the effect studies in these SCBA is very important to get useful information.

A full SCBA is not always necessary to get an indication of the financial consequences of the effects. For that reason there are some variants of the SCBA. In these variants less accurate information of the effects is given as by the full SCBA. The advantage of these SCBA variants is that they are easier to adapt, but still contain the systematic form and economic knowhow. A disadvantage of these variants is that the conclusions contain more uncertainties, due to the use of less accurate input. The following variants of the SCBA are possible (Faber, Mulders, Politiek, & Ministerie van EZ, 2012):

- Quick scan SCBA: This variant uses substantiated assumptions, which indicate the size of the effects in relation to the costs. This quick scan SCBA only contains the most important costs and benefits;
- Key-figures SCBA: The key-figures SCBA works in accordance with a complete SCBA, with the difference that the key-figures SCBA makes use of general key figures defined in other studies. A disadvantage of this SCBA variant is that not all the possible effects have own key figures;
- Full SCBA: Hereby all the possible effects are quantified in terms of money. The effects which cannot be quantified in terms of money will be described as complete as possible in the SCBA. In a full SCBA more than one alternative will be researched.

2.2 INPUT FOR THE CALCULATION OF THE TRAVEL TIME BENEFITS

This paragraph will describe the travel time benefits. The travel time benefits are used to include the travel time savings into an SCBA. The travel time benefits is the most important benefit post in an SCBA when it comes to line infrastructure, like roads, railways, channels, etc.. In addition, the travel time benefits are often used as basis for the calculation of the indirect effects. The indirect effects are mostly determined by a percentage incensement on the travel time benefits.

The travel time benefits are calculated using the “value of travel time” and the output of the traffic models. These subjects will be described in the following sub paragraphs.

2.2.1 VALUE OF TRAVEL TIME (VoTT)

There are two different interpretations of a VoTT and each interpretation has its own goal. The first goal is to determine the effect of the policies on the ground, hereby is meant policy changes like implementing toll roads. For example if a toll road saves ten minutes of driving time and costs 5 euro, than the VoTT will be used to estimate how many travellers will switch to that toll road. The second goal is that travel time saving benefits are calculated using the VoTT (Fowkes, 2010). This second point is of importance for this report.

The VoTT should be used to determinate travel time savings in terms of money. The VoTT is the opportunity cost of the time that the traveller spent on the journey. It is possible to use that value in a SCBA when an average VoTT is determined.

There are different methods which can be used to determine the VoTT. Example models are based on stated preference- (SP) information, revealed preference (RP) information or cost savings or resource costs approaches (Shires & de Jong, 2009). The cost savings or resource cost approach uses the wage rate or a fraction of the wage rate as the VoTT. With a SP or RP model, respondents get a choice set whereby they have to make trade-offs between time and money. This is basically the amount of money that the traveller is willing to pay in order to save travel time, or opposite, the amount of money the traveller would accept as compensation for the added travel time (Litman, 2009).

2.2.2 TRAFFIC MODELS

Traffic models provide important information for the SCBA and have impact on all three different types of effects described in the SCBA (Celissen, 2007). The traffic models deliver information on the travel time savings, the transport volume and the reliability. This information is also used as input for the indirect effects, because indirect effects are related to the direct effects. For the external effects the traffic models generate the input for the aspects: traffic safety, environment, air and noise.

The information of the travel time savings is based on:

- Vehicles at aggregated origin / destination level;
- Movements at the aggregate origin / destination level;
- In this distinction is made by day part, and travel purpose.

The information of the transport volume is based on:

- Vehicles kilometres at aggregated origin / destination level;
- In this distinction is made by day part, and travel purpose.

In The Netherlands three different types of traffic models are mostly used by the policy makers. These three traffic models are called the Landelijk Model Systeem (LMS), the Nieuw Regionaal Model (NRM) and the Regionale BenuttingsVerkenner (RBV) (Rijkswaterstaat, 2005).

The LMS mainly focuses on the national highway network and supplies forecasts the Dutch personal mobility for 15 to 20 years. This forecast among others will take into account the demographic and socio-economic developments. With the LMS it is also possible to forecast the effects of possible changes on the national highway network, for example what the effects are of a new connection in the network. The LMS services the policy makers of the ministry by determining the long term policy.

The NRM is the regional derivative of the LMS. Information of the LMS is therefore used as input for the NRM. The goal of the NRM is to focus on the bottlenecks that were found in the LMS. The NRM also supplies a forecast of the Dutch personal mobility for 15 to 20 years. It is possible to research the effects of a more regional policy since the network the NRM focuses on is much smaller. For example the implementation of an extra travel lane or the planning of a new residential area. The NRM is mainly used by the regional services of Rijkswaterstaat (RWS), provinces and the bigger municipalities like Amsterdam and Rotterdam.

The information of the NRM can be used for the RBV. The RBV distinguishes itself because it calculates the effects of utilization measures, for example the effects of rush hour lanes and traffic regulations. The model is meant for forecasting a short period of 5 years and only focuses on car drivers. The RBV is mainly used by cooperating road authorities.

All the three different models calculate the traffic- and transport figures on a working day level. The models can give their outcomes for different transport purposes; business, commute and other. In some cases it is also

possible to make a distribution of other traveller characteristics; some examples are the income category-, and the family situation (Immers & Stada, 2011).

There are different options to generate results of the models. These different options have influence on the outcome of the models and the SCBA's, because the outcomes of the models are used for the calculation of the most important benefit. For this reason is it important that the information of the models is generated in a fixed manner and that there are standard methods for the implementation of this information in the SCBA. For this standardization two aspects are of interest (Donkelaar & Mulder, 2011).

1. The information should better suit the way in which, according to the OEI, welfare effects are determined;
2. It is of great importance that all the studies are performed on the same manner. Only in this way it is possible to compare the different outcomes.

3 PHASE A: CALCULATION OF THE TRAVEL TIME SAVING BENEFITS IN THE NETHERLANDS

This chapter will provide a review of the current Dutch situation. With the current Dutch situation is meant the manner how the VoTT is determined and applied in Dutch SCBA's.

The first paragraph will describe how the VoTT is determined in The Netherlands. The second paragraph will describe how the VoTT is implied in the SCBA. Several possibilities of improvement on both aspects will be defined in the third paragraph. These possible improvements will be used as input for the next chapter. The final paragraph will show a short summary of this chapter.

3.1 THE DETERMINATION OF THE VoTT IN THE NETHERLANDS

3.1.1 VALUE OF TIME RESEARCH

This first Dutch VoTT advise was published by the Adviesdienst Verkeer en Vervoer (AVV) in 1991. This VoTT was based on an empiric research performed over the years 1986-1990. The empiric research was performed by the Hague Consultancy Group (Adviesdienst Verkeer en Vervoer, 1998). Over the years the VoTT were updated using inflations figures and more recent Onderzoek VerplaatsingsGedrag information (Hague Consulting Group, 1998). By the users of the VoTT the need to update these VoTT was growing over the years. In order to meet the demands of the users the AVV commissioned this research in again 1997. The 1997 research was performed by the same consulting firm as the previous research. The results of this research were published in the report 'Value of Dutch Travel Time Savings' in 1998. The outcomes of this report are used for the current VoTT key-figures set by RWS (Rijkswaterstaat, 2006). Recently a new VoTT research carried out by the consulting firm Significance. The results of the new research were not yet published on the date of writing this report. For that reason this report describes a short summary of the 1998 VoTT research and only discusses the differences in methods used for the new research.

The design of the 1988 survey was followed closely in the 1998 survey. The reason for this was that one of the goals was to allow comparability between the both studies. However, some changes to the survey were made to reflect the differences that appeared in society over the nine years between the researches. Some examples of these changes are, use of mobile phone during the trip, income categories and ticket prices (Hague Consulting Group, 1998).

For the 1997 research an overall target was to have 5000 usable interviews divided into three travel purposes; 2500 commuting, 1500 other and 1000 business. The recruiting of interviewees took place on several locations in The Netherlands. For car drivers the recruit locations were at petrol stations along the highways and car parks in the city centre. In total 16000 recruiting forms were produced, of which 10817 were used, to reach the goal of 5000 usable interviews. After a couple days the recruited respondents received a questionnaire. Of the 10817 recruited interviews only 59% was usable thanks to not returned questionnaires or unusable answers. This is a total of 5157 usable questionnaires (Hague Consulting Group, 1998). The questionnaire exists out of three phases:

- General questions concerning the trip made during the recruitment;
- The SP design;
- General questions regarding the respondent and his household.

Given the fact that there were a couple of days between the recruitment of the respondents and the receiving of the questionnaire, it was of importance to summarise the trip on which the respondent was recruited. This was especially necessary for the first part of the questionnaire. In this first part various questions were asked

regarding the trip made during the recruitment. Some examples of the questions are: how many persons were there in the car? Did there was a traffic jam during the trip? Are the travel costs paid by someone else? The questions may slightly vary per travel mode (Veldkamp, 1997).

The second part of the questionnaire was an SP survey. In total the respondents had to answer 12 pair-wise choices between alternatives of changes in travel time and cost. There was one 'check' question whereby one option was both faster and cheaper than the other option. This 'check' question was added to test if the respondent understood the SP choice task. An example of an SP question is:

A <input type="radio"/>			B <input type="radio"/>		
Travel time	same	as now	Travel time	20 min shorter	than now
Travel cost	same	as now	Travel cost	f 2,00 higher	than now

FIGURE 2, EXAMPLE SP QUESTION

The alternatives varied per transfer mode and total travel time. In the SP questions the attributes time and cost varied according to the travel time class the respondent reported during the recruitment survey. The amount of travel time variations followed the following logic:

TABLE 1, TRAVEL TIME VARIATIONS (GUNN, 1998)

For trips of	Travel time change presented
45 minutes or less	5 and 10 minutes
46 to 90 minutes	10 and 20 minutes
91 to 135 minutes	15 and 30 minutes
136 minutes or longer	20 and 40 minutes

The variation of costs was based on an amount of cents per minute, which varied for the 12 choices.

The third part questions were asked regarding the respondent and his household. These set of questions was equal for all the respondents, disregard travel mode or trip length. Some examples of these questions are: age? Type of job? Income class? In these questions the most interesting change was the update of the income classes (Veldkamp, 1997).

THE DATA OF THE SP MODELS PROVIDE THE BASE FOR CALCULATION OF THE VOTT FOR INDIVIDUALS, POPULATIONS OR SEGMENTS OF POPULATIONS (HAGUE CONSULTING GROUP, 1998). THE OUTCOMES OF THE CALCULATIONS CAN BE FOUND IN THE TABLE 2 TABLE 3 AND

TABLE 4. IN TABLE 2 THE VOTT IS GIVEN PER INCOME CLASS AND TRAVEL MODE, IN TABLE 3 THE VOTT IS GIVEN PER INCOME CLASS AND TRAVEL PURPOSE AND IN

table 4 the VoTT is given per travel mode and purpose.

TABLE 2, VOTT BY INCOME AND TRAVEL MODE IN GUILDERS (HAGUE CONSULTING GROUP, 1998)

Gross monthly hh income		Car		Train		BT	
1988	1997	1988	1997	1988	1997	1988	1997
<2500	<3000	10.59	9.32	8.28	8.03	6.09	7.81
2500-4000	3000-5000	11.93	11.20	9.86	9.24	7.30	8.54
4000-6000	5000-7500	16.43	13.79	11.80	10.38	8.76	9.52
>6000	>7500	21.42	25.39	15.46	16.78	12.29	14.48
Total	Total	14.60	16.24	10.83	11.54	7.91	10.11

TABLE 3, VOTT BY INCOME AND TRAVEL PURPOSE IN GUILDERS (HAGUE CONSULTING GROUP, 1998)

Gross monthly hh income		Commuting		Business		Other	
1988	1997	1988	1997	1988	1997	1988	1997
<2500	<3000	11.20	11.14	24.10	17.41	8.88	7.63
2500-4000	3000-5000	11.80	10.98	33.83	27.08	9.98	8.45
4000-6000	5000-7500	15.82	11.93	46.12	34.93	11.32	9.29
>6000	>7500	16.31	19.84	58.66	73.17	13.87	12.67
Total	Total	13.75	14.43	45.64	48.37	10.59	9.64

TABLE 4, VOTT BY TRAVEL MODE AND PURPOSE IN GUILDERS (HAGUE CONSULTING GROUP, 1998)

	Commute		Business		Other	
	1988	1997	1988	1997	1988	1997
Car	13.87	14.51	45.76	50.18	11.07	9.99
Train	14.12	14.60	40.16	30.87	9.61	8.96
BT	11.56	13.55	40.04	23.69	6.82	8.61
Total	13.75	14.43	45.64	48.37	10.59	9.64

If one looks at the table which distinguisher's travel purposes, it becomes clear that business travel has a much higher rating as the categories commute and other. This higher rating for business travel can be explained by the fact that business travel has influence on two valuation aspects. First the VoTT of the employer and second the value of the extra productivity caused by the travel time savings.

In 1977 Hensher had developed a formula to calculate the VoTT for business travel containing these two aspects. The most important information of this formula exist out of three aspects. First, it is important to know which part of the travel time savings actually is used for business purposes, because the travel time savings may be used for both business and other purposes. Second it is important to know the part of travel time that is be used for business proposes, for example business related phone calls during the journey. And the last important input is the production value of a unit of working time. The formula as it was published by Hensher to calculate the value of business time savings is (Hensher, 1989):

$$TV = (1 - r - pq) \cdot MP + (1 - r) \cdot vw + r \cdot vl + MPF$$

Where in: TV = The value of saved travel time for business trips;

r = The share of saved travel time that is used for leisure;

p = The share of the time saved that was used productively;

q = Relative productivity of time saved that was used for work;

MP = Marginal productivity of labour;

VW = The value of the employee of saved travel time otherwise spent in work;

vl = The value of the employee of saved travel time otherwise spent in leisure;

MPF = The value of increased productivity of reduced fatigue.

This is the determining of the current VoTT, but as mentioned before - on behalf of the ministry of Infrastructure and Environment - a new research is performed by the consulting firm Significance. The

presentation ‘Values of Time and Reliability in passenger transport in The Netherlands’ given by De Jong, provide some differences in methods that are used in the new research.

The main difference between the both researches is the design of the SP survey. The 1998 SP survey existed out of one pair-wise choice, time versus costs. The new SP survey existed out of three pair-wise choices, time versus costs, time vs. costs vs. reliability and time vs. costs vs. reliability vs. variation (expected) arrival time (de Jong, et al., 2012). The research shall provide VoTT key-figures on the same levels as the previous study. So they only will provide key-figures that are dependent on travel purpose and travel mode. There are two main differences in the results between the both studies. The VoTT on average is decreased with 16 percent comparing with the current VoTT. The second difference in result is that they found different valuations between short length trips and long length trips (Bates J. , 2012).

3.1.2 ANNUAL ADAPTION VOTT KEY-FIGURES

The outcomes of the research made by Gunn in 1998 are used by RWS to determine the key-figures for the VoTT till at least 2012. The department Dienst Verkeer en Scheepvaart (DVS) of RWS made an estimation of the key-figures for the VoTT for a period until 2040 (Rijkswaterstaat, 2006). For this future estimation they used four scenarios as described by the Centraal Plan Bureau (CPB) (CPB, 2004). The key-differences in these scenarios are:

- Regional Communities (national and public orientated): Annual labour productivity growth and economic growth are very low in this scenario;
- Strong Europe (international and public orientated): In this scenario are both the annual labour productivity growth as the economic growth are a bit higher as in the regional communities scenario;
- Transatlantic Market (national and private orientated): Annual labour productivity growth and economic growth are high in this scenario;
- Global economy (international and private orientated): In this scenario both the annual labour productivity growth as the economic growth are the highest of all scenarios.

These four scenarios all have different effect on subjects like, mobility, work, energy, cities, environment, etcetera. The scenario effects on these subjects are described on a webpage of the CPB (CPB, 2013). For the future estimation of the VoTT all these different effects have been used.

Every year RWS adjust the VoTT. For this annual VoTT adjustment RWS uses several factors. The most important factors are: annual income growth, gross national product and change in demographics (Warffemius, 2013). In table 5 the indexed VoTT figures of 2011 are shown.

TABLE 5, KEY-FIGURES VOTT FOR 2011 IN EURO'S (DVS, 2012)

	Commute	Business	Other	All motives
Car	9,71	33,61	6,70	10,84
Train	9,10	15,86	5,76	6,76
BT	9,78	20,69	6,02	7,70

3.2 IMPLEMENTATION OF THE VOTT KEY-FIGURES IN THE SCBA

This paragraph consists out of two sub paragraphs. First some general information is given about the use of SCBA's in The Netherlands. This general information mainly is concerning the history of the use of SCBA for infrastructure projects in The Netherlands and in which decision phase SCBA's are used. The second sub paragraph will provide information concerning the determination of travel time savings.

3.2.1 USE OF SCBA'S IN THE NETHERLANDS

HISTORY OF SCBA FOR BIG INFRASTRUCTURE PROJECTS IN THE NETHERLANDS

The OEI¹ guidance is established in 2000 conform the Dutch government decision that infrastructure projects are evaluated conform an integral review of all the social effects. The making of an OEI conform the guidance is required for all special governmental projects since the foundation in 2000. With special governmental projects is meant infrastructure projects of national importance.

For the determination of the OEI guidance, a research program was set to investigate the economic effects of infrastructure (OEEI²). The assignment for the OEEI was given by the combination of the ministry of Economic Affairs and the ministry of Transport and Water (Eijgenraam, Koopmans, Tang, & Verster, 2000). The main recommendation of the OEEI was the use of an evaluation method in the form of a SCBA. Hereby all the social effects can be estimated in terms of money. Which generate a transparent review of all the costs and benefits (Eijgenraam, Koopmans, Tang, & Verster, 2000). This SCBA will be further explained in the next paragraph.

Two years after the introduction of the guidance, on behalf of the ministry of Transport and Water, an evaluation of the OEI is made (BCI, 2002). One of the main conclusions of the evaluations was, that drafting the effects using a SCBA has contributed to the transparency and commoditization of the policy process (BCI, 2002). Some extra additions are made for the OEI guidance in the years following (Ministerie van Verkeer en Waterstaat, 2004).

The OEI guidance is used for almost all the MIRT³ projects. MIRT projects are projects where is a spatial intervention and which are included directly public founding. In addition, projects where the government is involved as a grant provider are also listed as MIRT projects.

SCBA IN MIRT-PROJECTS

The decision making process of the MIRT program exists out of three phases. In these phases the decisions are made from the beginning till the realization of the project. The three phases and the corresponding decisions are (Ministerie van Infrastructuur en Milieu, 2011):

- Exploration phase: This phase starts by taking the *start decision*. The purpose of this start decision is to establish the definition and delimitation of the problem. The goal of the exploration phase, after taking the start decision, is the 'funnel process'. During this process will be searched to a preferred alternative of many possibilities. The result of this process will be an agreement for an unambiguous and specific scope (preferred alternative). This agreement will be discussed during the *preference decision*;
- Plan development phase: During this phase the decision to legally and financially realize the preferred alternative will be prepared. This phase concludes with the *project decision*. The project decision will be connected to other policy decisions from other procedures;
- Implementation phase: The purpose of the final phase is the realization of the project. This phase concludes with the *realization decision* after the projects is realized.

¹ OEI stands for Overzicht Effecten Infrastructuur (En: Research program Economic Effects Infrastructure)

² OEEI stand for Onderzoekprogramma Economische Effecten Infrastructuur (En: Research program Economic Effects Infrastructure)

³ MIRT stands for Meerjarenprogramma infrastructuur, Ruimte en Transport (En: Multiannual program infrastructure, Space and Transport)
The MIRT will be explained in paragraph **Fout! Verwijzingsbron niet gevonden.**

During these three phases the decision moments operates as a sieve. There is no automatic flow from one phase to another phase, with exception of the realization decision (Ministerie van Infrastructuur en Milieu, 2011).

In this report the focus will be on decision process of the preferred alternative. So in the next paragraph the MIRT-exploration phase will be further elaborated in some more detail.

The decision making process of the MIRT exploration phase exists out of four phases; the start phase, analytical phase, assessment phase and decision phase. There are two selection moments during these four phases. At the first selection a top three of possible alternatives is formed. At the second selection moment the final preferred alternative will be chosen. In the next text the four phases will be described in more detail (Miniserie van Infrastructuur en Milieu, 2012)

- Start phase (decision moment 1): This phase start with the start decision. After a positive decision the project will be started, inter alia by the preparation of a plan of approach. After the project start the 'Notitie Reikwijdte en Detail niveau (Notitie R&D)' will be developed. Part of the Notitie R&D is the assessment framework to which later in the process, the solutions be assessed. In addition to the assessment framework the Notitie R&D includes substantive starting points for the exploration from EIA¹ and other tests and examinations;
- Analytical phase (selection 1): This phase starts with the development of various solutions for the problem as defined in the problem analyse. Based on a global review a 'top 3' of most promising solutions will be defined². During the process for this selection all the directors and other stakeholders are involved. The phase concludes by handing in the 'Notitie Kansrijke Oplossingsrichtingen';
- Assessment phase (selection 2): During this phase the second selection will be made. In this second selection the emphasis is on comparing and evaluating the most promising alternatives selected in the previous phase. The comparing of the alternatives will be supported with a SCBA. The final goal of this second selection is to get one preferred alternative out of the promising alternatives to.
- Decision phase (decision moment 2): In the final phase the preferred final decision will be taken. With that decision the preferred alternative is administratively recorded.

The duration from the start decision till the preferred final decision should take a maximum of two years (Miniserie van Infrastructuur en Milieu, 2012).

SCBA IN THE MIRT-EXPLORATION

As described in the previous paragraph a SCBA will be used in the MIRT-exploration. In the analytical phase it is not required to have a quantitative substantiation in the form of a SCBA. During the analytical phase expert judgement or a quick scan tool are sufficient for the assessment. In the assessment phase a SCBA often is used as a tool to compare the different the most promising alternatives. By using a SCBA the effects of the different alternatives can be reviewed in a structured and objective overview.

The SCBA shall be applied in the assessment phase, but also in the other phases actions will be taken. These actions are necessary so that the SCBA in the assessment phase can be performed in an effective way. An overview of these actions is given in table 6.

¹ EIA stands for Environment Impact Assessment (Dutch: Milieu Effecten Rapport MER)

² With a 'top 3' a range of solutions meant. This range has a minimum of 2 solutions and the maximum depends on the project scale

TABLE 6, ACTIVITIES SCBA DURING MIRT EXPLORATION PHASE (MINISERIE VAN INFRASTRUCTUUR EN MILIEU, 2012)

Actions	SCBA (OEI/SCBA)
Start phase	
Action 1: notitie R&D - fundamentals for the assessment framework	<ul style="list-style-type: none"> - Task-analysis/zero-alternative prepared for the purpose of a SCBA; - Check whether the effects of the SCBA are well entrained in the assessment framework; - If not, SCBA still include in the assessment framework.
Action 2: notitie R&D - alignment SCBA and other studies	<ul style="list-style-type: none"> - Alignment plan-EIA and SCBA: include the principles of the CBA and plan-EIA in the notitie R&D; - Alignment (traffic)calculation and SCBA: starting points, assumptions, to explore alternatives and output of the (traffic) model.
Analytical phase	
	<ul style="list-style-type: none"> - It is possible to quantify some effects during the first selection. That could be use by the selection of the 'top 3'.
Assessment phase	
Action 1: define scope SCBA	<ul style="list-style-type: none"> - Decide: customization or format SCBA by MIRT - Additional format: yes/no? - Distributional effects: yes/no? - Deviate from the framework ? - Second opinion: yes/no?
Action 2: perform SCBA	<ul style="list-style-type: none"> - perform SCBA.
Action 3: reporting	<ul style="list-style-type: none"> - Compose OEI-report (input structural concept); - Compose OEI-format with uniform explanatory notes; - Clarify references CBA / plan-EIA.
Action 4: quality assurance	<ul style="list-style-type: none"> - For test SCBA by DVS and WD (or extern test by rail projects); - Possible second opinion.
Decision phase	
	<ul style="list-style-type: none"> - Consideration solutions, including those based on EIA / SCBA.

3.2.2 DETERMINING OF THE TRAVEL TIME BENEFITS IN THE NETHERLANDS

The travel time saving are the most important direct effects of infrastructure projects and often the biggest benefit post in the SCBA. In The Netherlands the travel time saving benefits often are calculated for the three different travel purposes, other differentiations are not very common. As described in the second chapter the travel time saving benefits are calculated using the VoTT and the outcomes of the traffic models. The calculation of the travel time saving benefits for a road project is done in three steps.

First the total travel time savings of a project must be calculated. With use of the output of the traffic models the daily travel time saving of new infrastructure connections can be calculated by using the 'Rule of Half' (Donkelaar & Mulder, 2011). For infrastructure projects improvements like an extra lane the output of the traffic models would be enough to determine the daily travel time savings.

The 'Rule of Half' calculates the travel time savings for an average working day. The 'Rule of Half' should be performed on the most disaggregated level, so to parts of the day, per motif and origins / destinations. The formula for the 'Rule of Half' is:

$$Travel\ time\ savings = A^{for}(t^{for} - t^{after}) + \frac{1}{2}(A^{after} - A^{for})(t^{for} - t^{after})$$

Where in: A^{for} = Amount of movements reference situation

A^{after} = Amount of movements alternative

t^{for} = Travel time reference situation

t^{after} = Travel time alternative

The traffic models LMS and NRM which often are used by RWS to analyze the traffic, provide traffic- and transport patrons per travel purpose for an average working day. Therefore the outcomes of the models are on an average working day level. However a SCBA the is performed on a yearly level. For this reason should the outcomes of the traffic models need to be raised to a yearly level (DVS, 2010).

One of the problems that occur while raising the outcomes of the traffic models to a yearly level is the calculation of the traffic during the weekends and holidays. The traffic models do not have the option to generate these figures and deleting of weekends and holidays will lead to an underestimation of the travel time benefits. To solve this problem DVS provided multiplication factors for all three travel purposes. These multiplication factors are determined by two ratios (DVS, 2010):

- Ratio traffic weekend / working day: By using rules of thumb from the mobility research and the INWEVA traffic data are the traffic- and transport patrons of the weekends and holidays determined. This traffic- and transport patron is compared with the patron of working days. From there the ratios traffic weekend / weekday per travel purpose are determined, which are shown in table 7.

TABLE 7, RATIO TRAFFIC WEEKEND / WORKING DAY (DVS, 2010)

Travel purpose	Ratio traffic weekend / working day
Other	1.154
Commute	0.198
Business	0.155

- Ratio traffic hours rest day / natural day: To determine the ratio traffic hours rest day / natural day it is necessary to know the how many vehicles hours there are in a rest day compare to an entire natural day. With this information the ratio traffic hours rest day / natural day can be calculated. This ratio is the same for the weekend as for a working day, because it is very hard to qualitative estimate the travel time and costs for weekends and holidays. The ratios traffic hours rest day / natural day per travel purpose are shown in table 8.

TABLE 8, RATIO TRAFFIC HOURS REST DAY / NATURAL DAY (DVS, 2010)

Travel purpose	Ratio traffic hours rest day / natural day
Other	0.739
Commute	0.423
Business	0.723

DVS supplies recommended values for the amount of working days and weekends / holidays, these are 254 working days and 111 weekend days. So the calculation of the annual travel time savings per travel purpose is the travel time saving for working days + the travel time saving for weekends:

$$\text{Travel time saving for working days} = \text{total travel time saving of the traffic model} \cdot 254$$

$$\text{Travel time saving for weekends} = \text{only the rest day travel timesaving of the traffic model} \cdot 111 \cdot \text{table 7/ table 8}$$

The second step is the calculation of the annual travel time saving benefits. For this calculation the second important input, the VoTT, is needed. The travel time saving benefits per purpose are calculated by multiplying

the annual travel time saving times the corresponding VoTT. The VoTT is considered linear dependent, so half a hour travel time saving is half the VoTT and one minute is 1/60 of the VoTT.

Because the project will last longer than one year it is necessary to calculate the travel time saving benefits for the life time of the project, this is the third step. For infrastructure projects this life time often is set at 100 years. It is not possible to just multiply the annual travel time benefits times the amount of years, because the value of money changes over time. Therefore the present value of the travel time saving benefits must be calculated. The present value of the travel time saving benefits will be calculated by multiplying the annual travel time saving benefits times a discount rate (Ecorys, 2008).

3.3 OPPORTUNITIES TO IMPROVE THE TRAVEL TIME BENEFITS

Now that it is known how the Dutch VoTT is determined and implied in SCBA's, it is possible to show what possible improvements on the determination and implementation of VoTT might be possible. In the next chapter the possible improvements will be reviewed compared to foreign literature. In total five questions have raised for possible adjustments in the theory described above. These five questions are:

- Why is the smallest time threshold in the SP survey set on five minutes?
- Why are there only larger time choices with a longer trip travel time and smaller time choices with shorter trip travel time?
- Why was there not made use of a more variable VoTT for the calculation of benefits for relative and / or absolute small travel time savings?
- Why is there not a difference in travel time gains and travel time losses?
- Why is the VoTT dependent on income almost never used in SCBA's?

The questions and related optional improvements can be categorized into three groups. The first three questions reflect on the possible improvements related to small time changes. The second group is related to the difference between time gains and losses. The third and final group contains the question related to the use of income dependent VoTT in SCBA's.

3.3.1 SMALL TIME CHANGES

Two of the three questions related to small time changes are related to the design of the SP model. First, why are there no SP choices smaller than five minutes while some projects have smaller travel time savings. By setting the lowest time change threshold on five minutes it is quite conceivable that travellers can do certain actions thanks to the time savings. Which makes it possible that this timeframe will be valued higher. It is easy to imagine that by a lower time threshold fewer actions are possible to perform and therefore smaller time savings will be valued lower. So the remaining question is, whether it is possible to determine the VoTT for time changes below five minutes?

The other optional improvement that is related to the design of the SP survey is related to the time scale choices by the total trip duration. When the total trip duration is longer the time variation options will be larger see table 1. Therefore only relatively large travel time difference are examined during the questions. While it is not hard to imagine that a time difference of ten minutes is lower valued by a trip duration of two hours than during a trip of half an hour. From the traffic models it is possible to calculate the relative time change in terms of percentage groups, so if there is a relative VoTT connected to these percentage groups these options could be possible. So the question that remains is, whether it possible to determine a relative VoTT which is dependent on the total journey duration?

The last option is more or less the same as the first option and focuses again on the absolute small travel time changes. Unlike the first option, which involved the determination of the VoTT of small travel time changes, this option has influence on the implementation of the VoTT of small travel time changes in SCBA's. The question with this option is, whether the VoTT is linear dependent on the time, so one minute is 1/60 of the VoTT. Or should the VoTT of small travel time savings be less than 1/60 of the VoTT, making use of a specific percentage of the VoTT. This option was also mentioned by two respondents in a research of Mouter e.a. (2012). They stated that small travel time savings should be calculated in a more accurate way, because most of the (SP) researches show that small travel time savings are valued lower.

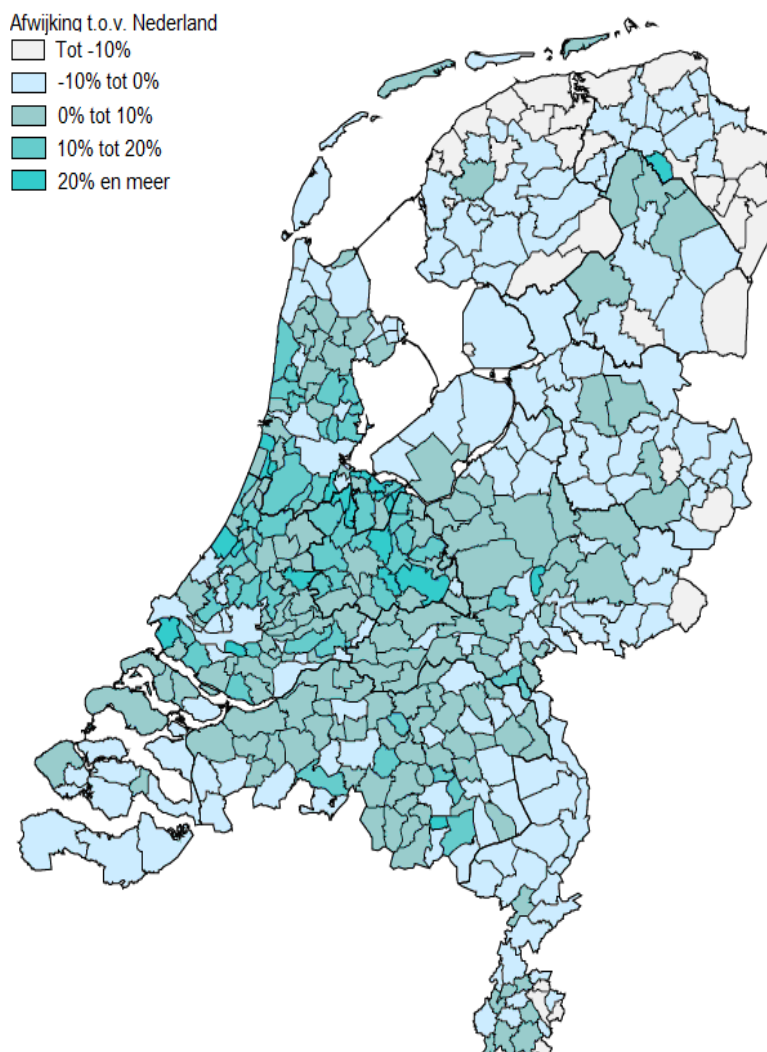
So to improve the accuracy of the travel benefits by analyzing small travel time changes, the following questions should be explored in the next chapter: Is it possible to determine the VoTT for (relative) small travel time savings and how can small travel time changes be implemented in SCBA's?

3.3.2 TIME GAINS AND LOSSES

One of the conclusions on the outcomes of the SP survey is that travel time losses are higher valued as travel time savings (Hague Consulting Group, 1998), but in the final key-figures presented in the report of the Hague Consulting Group and RWS there is not a difference in travel time losses or savings.

Therefore during the next chapter the difference in gains and losses and whether they should be implemented in SCBA's will be explored? And if so, how should it be implemented in SCBA's?

3.3.3 INCOME DEPENDENT VoTT



The next possible improvements have their origin in the implementation of the VoTT into SCBA's. The current differentiation of the VoTT exists out of three transfer modes (car, train and tram/metro) and three travel purposes (commute, business and other). While the results of the research of Hague Consulting Group input generates for more differentiation as currently used.

This option is about the use of income related VoTT figures. These income related VoTT figures are calculated in the research of Hague Consulting Group, but are rarely used in SCBA's. Use of these income related VoTT figures could have two advantages. First there will be more differentiation what can result into a more accurate calculation of the travel time savings benefits. A second advantage is that the results of the travel time saving benefits will be more region dependent. This second point can be explained by

FIGURE 3, DEVIATIONS INCOME DISTRIBUTION (CBS, 2012)

the fact that the average incomes vary per region. figure 3 shows the average income per municipality (CBS, 2012). The figure clearly shows that the economically strongest Dutch region, the Randstad, has an average income that is higher than the other regions of The Netherlands. So when the income related VoTT figures shall be used in the SCBA's the economic stronger region Randstad will generate higher travel time benefits than economic weaker regions with the same traffic volume.

Thanks to the implementation of income related VoTT figures and therefore the possibility to differentiate to regions a solution could be given for the critic given by Van Holst. According to Van Holst it was not done to equally value 15 minutes of travel time savings in the Randstad to 15 minutes of travel time saving in a weak economic region. Because the expected economic effects due to the travel time savings in the Randstad is higher as the economic effects related to the 15 minutes travel time savings in a weak economic region (van Holst, 2010).

In the next chapter a theoretical exploration shall be performed on the question, whether it is possible to implement more income dependent VoTT key-figures into SCBA's?

3.4 CONCLUSION

From the current calculation of the Dutch travel time saving benefits some main conclusions can be drawn. The VoTT in The Netherlands is determined by use of an SP research. Figures in that SP research VoTT are calculated per hour, travel purpose, income class and travel mode. So there is no differentiation in the VoTT for small or longer travel time changes or no difference in time savings and time losses.

The calculation of the travel time benefit is done with the use of the 'Rule of Half' and some other ratios that determine travel time savings, which are multiplied with the VoTT and a discount rate. In this calculation there is often only made use of the differentiation per travel purpose. The option to differentiate to income classes is almost never used. Also, the VoTT in this calculation is considered to be linear dependent.

The determination of the Dutch VoTT and implementation in the SCBA resulted in five questions which can influence the accuracy of the travel time benefits. From these five questions, three are specific issues which can possible improve the determining of the travel time benefits. These issues will form the basis for the next phase. In the next phase these issues will be compared to general literature and VoTT studies of foreign countries. The three issues are:

- **Small travel time changes:** This requires an exploration whether it is possible to determine another VoTT for (relative) small changes in travel time, and how these VoTT can be used in SCBA's;
- **Time gains and losses:** This will require an exploration on whether it is useful to implement an extra differentiation in SCBA's and if so how it should be implemented;
- **Income dependent VoTT:** This requires an exploration on the possibility of the implementation of income dependent VoTT key-figures.

4 PHASE B: REVIEW ON THE THREE POSSIBLE IMPROVEMENTS

The previous chapter has shown that there are three improvements possible for the determination and use of the VoTT. These three possible improvements are:

- Small time changes;
- Time gains and losses;
- Income dependent VoTT.

During this chapter the feasibility of these possible improvements will be examined by using foreign VoTT studies and (if there is available) additional general literature. Each paragraph will review one possible improvement. The paragraphs have the following format: first a review will be given of the foreign VoTT studies, second a review of the general literature and third some conclusions about the feasibility are given.

4.1 FOREIGN VOTT STUDIES

For all the possible improvements the following foreign VoTT studies are reviewed: Denmark, United Kingdom (UK), Norway, United States (US), Sweden and Switzerland. The following text will describe a sort summary of the research methods used to give a better understanding of the different foreign VoTT studies.

DENMARK

The Danish ministry of Transport and Energy launched the Danish VoTT study as a result of the worth of VoTT in a SCBA. In Denmark the VoTT benefits are often decisive for whether a project yields a positive or negative economic net benefit. For the Danish VoTT study the researchers had an overall dataset encompassed four SP experiments (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a).

- Experiment 1: Abstract time-cost exercise examines trade-offs between in-vehicle travel time;
- Experiment 2: Disaggregated time components examines trade-offs between hypothetical alternatives of the chosen mode and constrains both in-vehicle and out-of-vehicle travel components;
- Experiment 3: Alternative mode exercise considers time/cost trade-offs for an alternative mode;
- Experiment 4: Transfer price questions.

The data of experiment 3 was excluded from the project at its inception due to resource constraints. Also the data from experiment 4 was found out to be problematic and these data were not used for estimating the VoTT. So the VoTT of Denmark was based on the first two experiments, which will be further elaborated.

The first SP experiment was used to estimate the central value of in-vehicle travel time. During the SP experiment the respondents had to choose between two alternatives, described by travel time and travel costs. The choice options in the SP survey were relative to a recent actual trip which was been made by the respondent. During the SP survey four types of choices were generated (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study; Results for experiment 1, 2007b):

- Willingness to pay, comparing the reference to a faster but more expensive trip;
- Willingness to accept, comparing the reference to a slower but cheaper trip;
- Equivalent gain, comparing trips that are either faster or cheaper than the reference trip;
- Equivalent loss, comparing trips that are either slower or more expensive than the reference trip.

Beside the SP experiment was an interview which provided the background variables. These background variables are socio-demographic (e.g. sex, age, income, etc.) and details of the reference trip.

The outcomes of the SP experiment and the interview were used to determine the value of in-vehicle travel time. For the determination of this value they formulate a mixed logit model.

The second SP experiment was used to produce relative VoTT for some different components of travel time. Most of the respondents which participated in SP experiment 1 also participated in the second SP experiment. The second experiment was similar to the first experiment except that several components of travel time were allowed to vary independently. The following components were variable for car drivers and passengers (Fosgerau, Hjorth, & Lyk-Jensen, 2007c):

- Free flow driving time;
- Additional time due to congestion;
- Access/egress walk time;
- Time spend searching for a parking space.

The time values are inferred from binary choices between alternative routes characterised by their cost and a vector of travel time components. To estimate the values of different travel time components they modelled respondents choice behaviour using a mixed logit model.

Finally the Danish report concludes with a recommendation in favour of using a single average VoTT for an average kilometre of in-vehicle time. The VoTT is set 67 DKK per hour and there is no distinction between trip purposes and travel modes.

Besides this central VoTT the report gives some recommendation regarding the relative values of in-vehicle and out-of-vehicle time components. Examples of these components are parking search time and access/egress walking time.

UNITED KINGDOM

In 1994 the department of transport commissioned a further study of the VoTT on UK roads. This study was performed by the Hague Consulting Group, which also wrote the Dutch VoTT study. In 2003 Mackie et al. reviewed the evidence, relevant principles and practical considerations to make new recommendations on the UK VoTT.

In the report of Mackie et al. (2003) a reanalysis is made of the Hague Consulting Group data. The data of the Hague Consulting Group was gathered by using a SP experiment. In this SP experiment the respondents had to answer eight choice situations based on the variables travel time and travel costs. The value of the variables were dependent on the traffic conditions and the length of the journey of the reference trip from the respondent.

The eight choice situations consisted of four types of choice options:

- A choice between an option which was slower than the current journey and an option which was more expensive, all other things equal;
- A choice between an option reflecting the current situation and an option which was slower but cheaper than the current situation;

- A choice between an option which was faster than the current journey and an option which was cheaper, all other things equal;
- A choice between an option reflecting the current situation and an option which was faster but more expensive than the current situation.

The SP experiment presented the choice situation relative to the reference journey of the respondent. For example, choice options were presented like: travel time same as now; costs 20p lower than now. The data was analysed in three separate groups referring to the journey purposes; business, commuting and other.

After analysing the data from the SP experiment, Mackie et al. (2003) recommends VoTT key-figures for different travel modes and travel purposes, and in some situations they recommend income dependent VoTT key-figures.

NORWAY

In Norway the VoTT is probably the most important parameter in a SCAB. Therefore the main purpose of the Norwegian VoTT study is to provide both theoretically and empirically correct VoTT figures. The researches want to indicate some important issues that affect the VoTT. Some of these issues are (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997):

- VoTT in long distance travel (inter-urban > 50 km), vs. short distance travel (urban <50 km);
- Value of small time savings;
- Symmetry in value of time savings and losses;
- Role of income in VOTT.

The Norwegian study is limited to passenger travel within Norway and focuses on private travel and business travel. For private travel purposes two alternative approaches have been used for the determination of the VoTT. A SP survey technique and a transfer price technique. For business travel purposes they have made use of the Hensher's approach (see page 13).

In the SP survey each respondent was given two SP choices, one for the chosen mode and another for an alternative mode the respondent would choose for the same trip. This was to evaluate the mode specific differences of the VoTT. In total the respondents had to answer nine SP questions, each question contained two choice options. The choice options contained three variable attributes; time, costs and travel mode. The data of the SP survey is analysed by using a logit model.

After the SP survey the respondents had to answer the transfer price questions. During this part the respondents were asked to state their willingness to pay for time savings or willingness to accept for time losses. For the data resulting from the transfer price technique, regression models have used to address the distribution of the VoTT.

The Norwegian study concludes with presenting their results for two travel purposes, business and private. For both travel purposes an in-vehicle VoTT is presented for inter-urban travel (trips > 50 km) and urban travel. For urban travel, beside the in-vehicle VoTT, a VoTT is presented for the walking time and delay.

UNITED STATES

The department of Transportation uses SCBA for evaluating competitive funding applications of their programs and projects. In these SCBA's the VoTT is a critical factor for the evaluation of the benefits of transportation in infrastructure investments. The Department of Transport published its first guidance on this topic in 1997.

Recently in 2011 the Department revised this guidance and in that revised guidance they divined a new VoTT (Belenky, 2011).

The approach of redefining the VoTT was done in three steps. First the determinants of the VoTT were discussed. These determinants are: trip purpose, personal characteristics, hourly income, mode/distance and comfort. In the second part they analysed and combined foreign VoTT studies. Finally they determined the VoTT for department of Transportation applications.

In the US the VoTT is determined by using a percentage of the hourly income. The VoTT is given for the travel purposes: personal and business, and divided into local- and intercity travel. Also the VoTT is divided for two different travel modes: surface modes (all combination of in-vehicle and other time) and air/high-speed rail travel (only for intercity travel).

SWEDEN

The purpose of the Swedish VoTT study was to provide VoTT for new guidelines for project evaluation. The VoTT for private trips that had been used previously were based on RP studies concerning local and regional traffic. For business travel, wages plus overheads were used together with an assumption of the share of travel taking place during work hours. These values were debated for some time and the need for a broader and more consistent knowledge concerning the VoTT was recognised (Algers, Dillén, consultancy, & Widlert, 1996).

The theoretical base for this new Swedish VoTT study was in principle the same as used for the Dutch and UK VoTT studies. For private trips they used the neo-classical model of individual utility maximisation, under cost and time constraints. For business trips they used the Hensher's approach (see page 13).

The data was gathered by using a SP survey and was analysed using logit models, yielding the relevant time and cost coefficients. The questionnaire was divided into two phases, one for short distance trips (less than 50 km) and one for long distance trips (more than 50 km). The design of the SP survey was organized so that it was possible to estimate the VoTT for different alternative modes. Therefore the choice situations of the SP survey were designed so that the respondent was presented one base alternative, and a change from this alternative.

To gather information on the value of time losses as well as time savings, changes representing gains and losses were presented equally often in the survey. At an early stage, distance and income effects were analysed using a type of segmentation approach.

The Swedish report present their VoTT results for two travel purposes: private travel and business travel. A different in-vehicle time VoTT for private/business travel was given for trips shorter and longer than 50 km. Also an income dependent VoTT was presented for private/business travellers.

SWITZERLAND

Earlier Swiss VoTT figures were derived from RP sources or by transfer from other estimates. The current Swiss VoTT key figures are estimated by using SP data. In line with other European studies the SP survey was based on observed trips.

Initially the questionnaire of the Swiss VoTT study consisted of four parts: three SP experiments with each six or nine choice situations and a fourth part covering various socio-demographic and trip related questions. The levels of the choice variables vary in each experiment. The three experiments are (Axhausen, König, Abay, Bates, & Bierlaire, 2003):

- Experiment 1: Is a travel mode choice experiment. The respondents who have a car available had to make choices between car and bus or rail. Some of the variables in this experiment were travel mode, travel time, travel costs, number of changes (for public transport) and congested time (for car drivers);

- Experiment 2: Is a route choice experiment. In this experiment some respondents received choice experiments with the mode they chose for the reported trip. Some of the variables in this experiment were travel time, travel costs, number of changes (for public transport) and congested time (for car drivers);
- Experiment 3: Is a destination choice experiment. The respondents was asked to choose between two chopping centres. Herein was one chopping centre cheaper but further away than the other. Variables in this experiment were travel costs, travel time and price basket of goods.

For the main study the researchers only used the first two SP experiments. Third experiment unfortunately resulted in VoTT's estimates too high to be plausible. For that reason the third experiment was dropped from the main study.

The results obtained here use the basic multinomial logit formulation, as well as different extensions which allow taste differences between individuals, as well as error scale differences between the different SP's.

Finally the Swiss VoTT research present their VoTT figures for two transport modes (public transport and car) and for four travel purposes (commute, shopping, business and leisure).

4.2 FIRST POSSIBLE IMPROVEMENT: SMALL TIME CHANGES

In this paragraph a review will be given of the first possible improvement: a different valuation of small time changes. This possible improvement suggest that there should be a different valuation for small time changes, because the expectation is that the actual benefits will be lower for small time savings. As is described in paragraph 3.3.1..

Already known from the Dutch VoTT research is that smaller time changes are valued lower than bigger time changes. Also is known that in The Netherlands small time saving benefits are calculated with a time constant VoTT key-figure.

During this paragraph will be examined whether or not other VoTT studies find different valuations for small time savings and what these studies recommend on this subject. Furthermore will be examined what general literature suggest on the subject.

4.2.1 WHAT DO FOREIGN VOTT STUDIES SAY ABOUT SMALL TIME CHANGES?

DENMARK

In Denmark two SP experiments were performed. The data of first SP surveys showed that there is a clear difference in the VoTT between small and larger time changes (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a). In table 9 the average VoTT per hour is given for different levels of time changes starting from a time change of 3 minutes up till a time change of 45 minutes.

TABLE 9, MEAN VOTT FOR DIFFERENT LEVELS OF TIME SAVINGS IN DKK PER HOUR (FOSGERAU, ET AL., 2007A)

	$ \Delta =3$	$ \Delta =5$	$ \Delta =10$	$ \Delta =15$	$ \Delta =20$	$ \Delta =30$	$ \Delta =45$
Car driver	50	55	66	81	98	98	98
Car passenger	38	40	47	55	64	86	86
Bus	22	24	30	37	37	37	37
Metro	35	41	62	94	94	94	94
S-Train	28	31	37	45	45	45	45
Train	40	42	48	56	64	85	128

The table shows that the mean VoTT per hour increases when the level of time change increases. Another remarkable discovery from the table is that the VoTT per hour becomes constant after a certain time threshold. For example, the VoTT per hour for car drivers stopped increasing for time changes larger than 20 minutes. While the VoTT per minute decreases by time changes smaller than 20 minutes. With the results from the first SP experiment it would be logical to conclude that there would be a different VoTT for small travel time changes. Still the Danish VoTT report recommends the use of a time constant in-vehicle VoTT.

The reason for this recommendation is that the report assumes that the VoTT for small travel time savings is not a 'true feature' for the VoTT, but is caused by the artificial nature of the experimental design. The report indicates that by making use of an SP experiment the following problems can occur (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a):

- In a choice situation respondents will ignore time savings that are too small to 'matter'. Meaning that these small travel time savings are difficult comparable to the entire journey time or to the variation in journey time (delays) which they experience from day to day;
- Respondents sometimes find that small time savings are of less value, because they are too small to reschedule their activities in order to make use of the extra time. This is a very short-term perspective and the researchers expect that over time a permanent time saving would benefit the schedule of the respondent. Referring the respondent to the recent single trip may cause that the respondent will not consider these long-term effects. Another important feature of the Danish data is that the reference trip is not a frequently made trip, which makes it even harder for the respondent to consider the long-term effects;
- If there are certain time savings that are too small to be used, because most activities take a minimum amount of time, Fowkes (1999 in, (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a)) shows that a procedure taking this into account and only valuing time savings if they contribute to disposable time intervals of a certain size, will yield the same average value of time as a constant time value procedure.

Finally the Danish report notes that the issue concerning the value of small travel time is still not satisfactorily resolved and remains an important topic for future research.

UNITED KINGDOM

In the study of Mackie et al. (2003) they reanalysed the outcomes of the SP experiment done by the Hague Consultancy Group. One of the goals was to investigate the relation between the VoTT and size of time change.

The data of the Hague Consultancy group strongly indicates that smaller time changes are lower valued. This was checked by running different estimation models. All models show that small time savings are valued lower than higher small changes. To illustrate this phenomenon the outcomes of their preferred model are shown in figure 4.

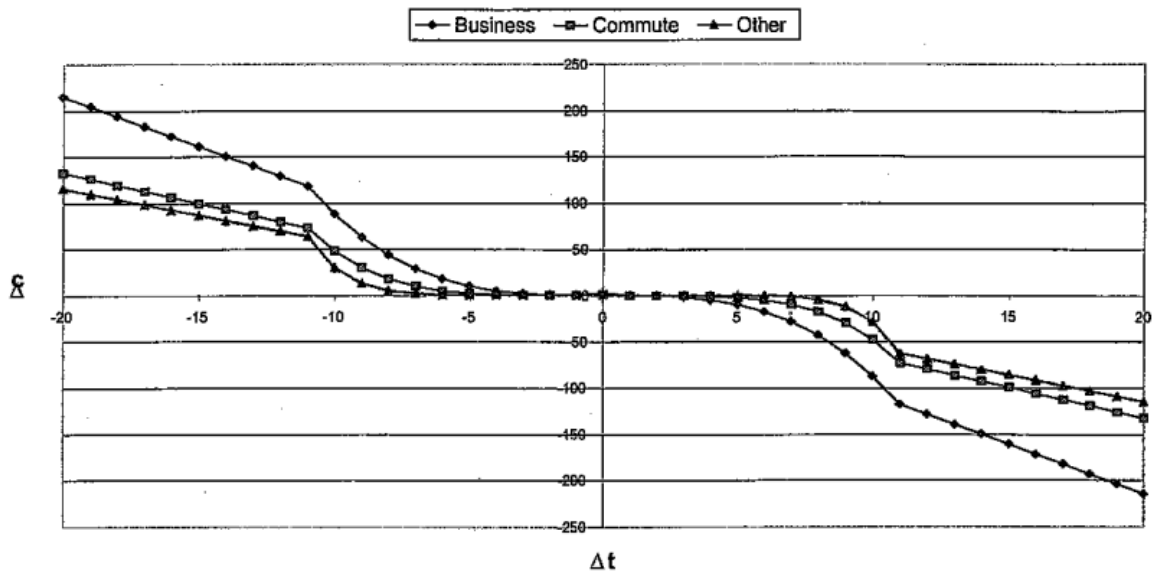


FIGURE 4, M8 MODELS WITH "PERCEIVED" TIME COEFFICIENT ($\theta=11$ (MACKIE, FOWKES, WHELAN, & NELLTHORP, 2003))

Despite the values found in the report, it states that it would be unwise to take these results at face value. The report gives here for two reasons. First, the results are inconsistent with the theoretical expectations on the shape of the indifference curve, at least when allowance is made for adjustments beyond the immediate short term. Second, it implies extremely high marginal values of time as the threshold of 11 minutes is approached.

The data is inconsistent because effectively it indicates that the VoTT for time changes between 0 and 6 minutes is more or less zero. The VoTT of time changes after 6 minutes till 11 minutes is around 12.8 p/min and thereafter it reverts to about 5 p/min. The report states that in general there are three explanations for these results:

- The data reflects real perceptions and preferences;
- The data relating to small time changes as presented in SP is unreliable. This is because people may believe that such large time savings would not actually come to pass and that small time savings are minor alongside day-to-day variation in car journey times;
- Alternative to the second point, people rate the time changes on a short term perspective. In that short term perspective small time changes will not affect the schedule and are therefore valued close to zero.

The first explanation cannot be ruled out, but the report states that their preference goes out to a mixture of the second and third explanation. So They believe that the lower values for small time savings are a result of the artificial nature of SP experiment, because the respondents are focussed too much on the short-term schedule. In addition unreasonable high marginal values of time are found between 5 and 11 minutes.

Hereof follows that the report suggest that the evidence cannot be used to support the use of very low or zero VoTT for small time changes (Mackie, Fowkes, Whelan, & Nellthorp, 2003).

An slightly older UK paper of Mackie *et al.* also defend the recommendation of the use of a time constant value (Mackie, Jara-Díaz, & Fowkes, The value of travel time savings in evaluation, 2001). This paper rejects the argument that small travel time changes have a lower value because these changes are negligible. The paper stated that this argument is not correct, because if you shop at a supermarket that is just slightly cheaper as usual you will get this benefit without noticing the price difference.

Even older is a 1998 paper in which Wardman wrote about the VoTT in the UK. Again this paper concluded that small time changes were valued lower as bigger time changes in the SP survey (Wardman, 1998). Wardman also gives an argument against these conclusions that respondents do not take into account the long-term benefit on their schedule.

There are also UK reports in favour for the use of a different VoTT for small time changes. The report of Bates & Whelan give some conclusions why smaller time changes should have a lower value (Bates & Whelan, 2001):

- Small amounts of time are less useful than large amounts;
- Small time changes are said to often account for a large proportion of scheme benefits, so that small errors in measurement might mean that the scheme is really of no benefit to anyone;
- Allowing small time changes to have 'full' value is said to inflate the measured total of benefits and so lead to schemes being wrongly found to have sufficient net benefit to justify implementation.

Still Bates & Whelan (2008) doubt that SP surveys are suitable for carrying out the research to small time changes. They stated that by the fact that most SP designs refers to the 'current journey' respondents will not be able to make any structured choices. According to the report this effect could effectively vanish when a SP design does not include such a reference to the 'current journey'.

NORWAY

The Norwegian study had indicated that they want to research the value of small time savings. With the use of the second part in the research, the travel price questionnaire, they collected data concerning the willingness to pay or -accept for different time changes. The questionnaire was divided in a part for urban travel (< 50 km) and in a part for inter-urban travel (> 50 km). The lowest time threshold in these questions was 2 minutes for urban travel and 5 minutes for inter-urban travel.

In the data gathered by this questionnaire it is not possible to detect any change in VoTT concerning the size of time saving. This could be a result of the exclusion of very small time changes. However they did find a difference between the valuation of urban travel and inter-urban travel, as can be seen in table 10.

TABLE 10, IN-VEHICLE TIME VOTT IN NOK/HR (RAMJERDI, RAND, SAETERMO, & SAELENSMINDE, 1997)

	Trips < 50 km	Trips > 50 km
VoTT private car	39	86
VoTT business car	137	181

This difference could be explained by the fact that time savings as the same percentage of trip time for short distance travel is smaller than for long distance travel, and the smaller time savings could be valued lower. For example: Someone saves 2,5 min of an urban trip with a normal duration of 10 minutes or saves 15 minutes on an inter-urban trip with the duration of one hour. His willingness to pay per minute is higher for the 15 minutes time saving than his willingness to pay per minute for the 2,5 minutes time saving.

In the above example both time savings are relative 25 %, but there is a difference in valuation. As a result can be concluded that relative time savings are subordinated to absolute time savings.

The Norwegian research concludes with the recommendation that the VoTT of small travel time savings must be further explored, especially in combination with the total journey time.

SWEDEN

The Swedish VoTT research evaluated their SP results on income effects and distance effects. The distance effects were analysed using the same distance boundaries as the Norwegian study. Following that the results were divided into a group with trips shorter than 50 km and a group with trips longer than 50 km (Algers, Dillén, consultancy, & Widlert, 1996).

By separating the respondents into these two groups they founded that both the time parameter and the cost parameter varied according to the distance. In table 11 the values of in-vehicle time are presented for the separate categories.

TABLE 11, IN-VEHICLE TIME VALUES IN SWEDISH CROWNS PER HOUR (ALGERS, DILLÉN, CONSULTANCY, & WIDLERT, 1996)

	Trips < 50 km	Trips > 50 km
VoTT commute car	34	81
VoTT other car	27	-

The report suggest three possible reasons that may cause the difference in the VoTT between the two distance groups. The main reason is that short trips take less time, have smaller possible time changes and are lower in costs and therefore are valued lower than the longer trips which take more time, have bigger possible time changes and are more expensive. This is a small proof that the smaller time changes are one of the reasons for the lower value of the VoTT for small distance trips.

Beside the previous point the Swedish report did not give any conclusions and recommendation regarding the value of small time changes.

SWITZERLAND

The Swiss results does not show any differences regarding the size of the time change, but have, like Sweden and Norway, a distinction in travel distance and income (Axhausen, König, Abay, Bates, & Bierlaire, 2003). In figure 5 graphically is shown how the VoTT increases if the travel distance grows. In the graphic also is shown that this effect applies for all the income groups.

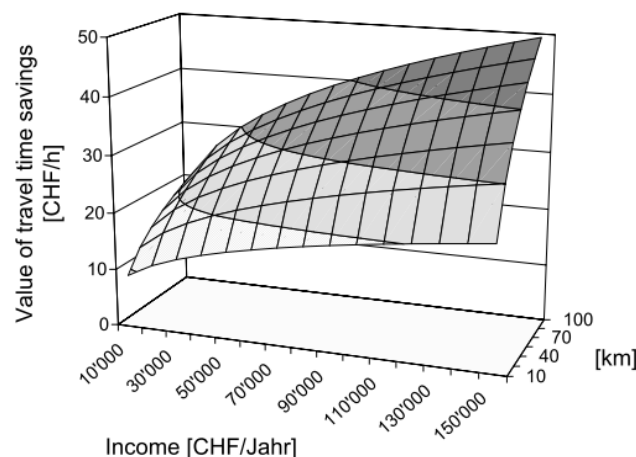


FIGURE 5, SENSITIVITY OF VOTT FOR CAR COMMUTERS (JOINT MODEL OF ALL SP EXPERIEMENTS) (AXHAUSEN, ET AL., 2003)

In another Swiss research they stated that further research to small time changes must be performed (König, Abay, & Axhausen, 2003). They say to test for non-linearity's, especially of small time savings, one can formulate the utility function using differences, their squared values and interactions.

UNITED STATES

The research of the US is the only research that is used for this report which did not use a SP experiment to estimate their VoTT. Instead they used literature and foreign VoTT studies to determine the ratio between average hourly income and the VoTT.

One of the specific topics they reviewed in the foreign VoTT was the size of time change (Belenky, 2011). In this part the report discusses whether or not the VoTT should be ignored in case when the time changes are smaller than a certain time threshold.

In advantage of the exclusion VoTT by small time changes, they refer to other researches (Australia Bureau of Transport, Fosgerau et al and Mackie et al.) who suggest the conclusion that small savings may have negligible benefits.

However there is not persuasive evidence where such a threshold might be for any population or how it could be used to predict an appropriate threshold for another. An even more important issue is that all changes in travel time results from governmental decisions that are composed of many smaller changes, and it would be impossible to identify particular changes considered big enough to affect each individual decision. So to evaluate the total impact of any governmental decision is assumed that the value of each minute of time is constant.

4.2.2 OTHER LITERATURE ON SMALL TIME CHANGES

When one looks at the integration of small travel time changes in SCBA's there in general are two main arguments in favour for the use of a time constant VoTT in SCBA's (Wartburg & Wartens, 2004). The first argument states that small travel time savings are useless for the majority of the travellers, but can be of extreme value for a small group of travellers. This argument suggests that there are time thresholds for activities distributed among the population. Therefore the value of small travel time savings will be zero or very small to most travellers, because they do not reach a time threshold for another activity. While for other travellers the value of small time savings will be substantial, because they are close to a certain time threshold. The second argument suggests that road projects must be seen in the context of the whole network. So all the projects are related to each other and therefore the small travel time savings per project must be combined to one big travel time saving for the whole network.

Most countries use a time constant value for small time changes, because of these reasons (Daly, Tsang, & Rohr, 2012). All the countries described in the previous paragraph use a time constant value for small time changes in SCBA's. However since 2011 the UK presents their time saving benefits in six bands: less than -5 minutes, -5 to -2 minutes, -2 to 0 minutes, 0 to 2 minutes, 2 to 5 minutes and more than 5 minutes (DfT, 2011). The guidance emphasizes that the new requirements are for reporting only: in the calculation of travel time benefits a uniform value of time is still to be used.

Still there are some countries who believe that small time changes should be implemented otherwise in SCBA's. Two examples are Germany and Canada (Daly, Tsang, & Rohr, 2012).

In Germany the Federal Ministry of Transport, Building and Urban Development published a guidance document that recommends that below a certain time threshold the VoTT for the non-commercial sector should be lowered with 30% (BMVBS, 2003). To support this decreased VoTT they state that experience has shown that people are not aware of journey time reductions in the non-commercial sector below a certain time threshold.

The Canadian transport guidance document contains a discussion on the treatment of small time changes (Wilson, Blanchard, Laprade, Moore, O'Keefe, & Wilson, 1994). The guidance states that any travel time change below 5 minutes is considered as small for non-commercial travel. They recommend that the value of small

travel time changes should be clearly identified in the SCBA, but should not be included in the net present value calculation.

To support the exclusion of small time changes from their benefit calculation they state that the possibility to turn these small time changes into real labour costs savings depends on whether the freed-up resources can be used to perform other productive activities.

Fowkes (2010) state that if there is a time threshold under which there is no value, such as the Canadian approach, there is a huge possibility that small time savings get undervalued. In his report he states that when there is a time threshold under which the VoTT is zero we have that amount of time available for combining with other small time changes. Eventually if enough small time changes are combine, the total time saving would be larger than the time threshold, then these combined small time changes are undervalued.

In his report Fowkes provides an example with chickens laying eggs that have to be boxed in sets of 6 for sale daily to illustrate the above. What than is the value of an extra egg? It is possible to say that it has no value, because without another 5 eggs it is impossible to sell it. But if there are exactly 5 eggs left over from that days production (on a one in 6 chance), that extra egg provides the opportunity to sell 6 eggs. So 5 out of 6 six times the extra egg is worthless, but once in 6 times it is worth 6 eggs. So Fowkes claims that mathematically this threshold effect means that in the long run the value of all eggs (and so also minutes of time) are equal, no matter how many arrive at once.

By contrast, Professor Van Wee (TU Delft) believe that the VoTT per minute for small savings is lower than the VoTT per minute for bigger time savings. He made this statement in the Dutch television program 'Eenvandaag'. As conclusion of this statement he suggest that here for the travel time benefits for projects with small travel time savings are overvalued (Van Wee, 2013).

There are other methods to implement small time changes in a SCBA beside a fixed decrease of the VoTT, such as is used by Germany (70%) and Canada (0%). In a paper by Welch and Williams (1997) six VoTT implementation functions are provide and tested. In table 12 these six derivative unit value (DUV) functions are shown plus the 'normal' constant unit value (CUV).

TABLE 12, SPECIFICATION OF THE UNIT VALUE OF TIME FUNCTION (WELCH & WILLIAMS, 1997)

Descriptor	Functional form of $\Gamma[z]$	CUV Limit
CUV	$\Gamma[z] = 1$ for all z	
DUV: RAV¹	$\Gamma[z] = \theta$ for all z , $0 \leq \theta \leq 1$	$\beta = 1$
DUV: step	$\Gamma[z] = 0$ if $z \leq z^*$, 1 if $z > z^*$	$z^* = 0$
DUV: tapered (wedge function)	$\Gamma[z] = z/z^*$ if $z \leq z^*$, 1 if $z > z^*$	$z^* = 0$
DUV: tapered (GLD² function)	$\Gamma[z] = 1 - \phi (1 - z/z^*)$ if $z \leq z^*$, 1 if $z > z^*$	$\phi = 1$, $z^* = 0$
DUV: multiple step function	$\Gamma[z] = \phi_1$ if $0 \leq z \leq z^*$, ϕ_2 if $z_1^* \leq z \leq z_2, \dots$	$\phi_1 = \phi_2 = 1$
DUV: sigmoid form (e.g. logistical)	$\Gamma[z] = \{1 + \exp\{-\alpha (z - z^*)\}\}^{-1}$	$\alpha \rightarrow \infty$, $z^* = 0$

4.2.3 CONCLUSION ON SMALL TIME CHANGES

In table 13 is shown how the different foreign VoTT studies deal with the valuation of small travel time savings. In the table is shown whether the VoTT study has adopt a small time changes in their research design, whether there is a difference in results, whether or not they recommend another VoTT for small travel time savings for commuting car drivers and whether or not they recommend further research on the subject.

¹ RAV stands for Reduced Average Value

² GLD stands for General Linear Discounting function

TABLE 13 OVERVIEW VOTT STUDIES FOREIGN COUNTRIES CONCERNING TRAVEL TIME SAVINGS AND LOSSES

VoTT study:	Adopted in research	Difference in results	Recommendation VoTT	Recommendation for further research
Denmark	Yes, in SP design	Yes	Constant value	Yes
United Kingdom	Yes, in SP design	Yes	Constant value	Yes
Norway	Yes, in SP design	Distance related	Constant value	Yes
Sweden	Yes, in SP design	Distance related	Constant value	No
Switzerland	Yes, in SP design	Distance related	Constant value	Yes
United States	Yes, as specific review topic	No	Constant value	Yes
Netherlands	Yes, in SP design	Distance related	Constant value	No

In the foreign VoTT researches some cases observe that in the SP surveys the values for small travel time changes is valued lower as longer travel time changes. This applies for the results of the SP surveys from the UK and Denmark. In three other countries is found that the VoTT is related to the travel distance and therefore indirect to the travel time. In these three countries is found that when the distance decreases the VoTT decreases.

Still all these countries does not recommend a smaller VoTT for small travel time changes. The most frequently cited argument for rejecting the use of smaller VoTT is that current SP experiments are not suitable for the determination of small time changes. Most reports suggest that the following points lead to unreliable results for valuation of small time savings:

- Respondents will ignore time savings that are too small to 'matter'. Meaning that these small travel time savings are difficult comparable to the entire journey time or to the variation in journey time (delays) which they experience from day to day;
- Respondents sometimes find that small time savings are of less value, because they are too small to reschedule their activities in order to make use of the extra time. This is a very short-term perspective and the researchers expect that over time a permanent time saving would benefit the schedule of the respondent. By referring to the respondent to the recent trip they will not consider these long-term effects.

The research of Bates & Whelan state that some of these problems of the SP surveys could be solved by not referring to a specific journey in SP surveys. By referring to the current journey respondents will evaluate the alternatives on a short term view. This effects the choices the make in the SP experiments, because the respondents does not see the advantages of small time savings on a short term.

In other researches the results were not given differentiate to travel time, but to travel distance. In the three researches of Norway, Sweden and Swiss is the conclusion that the VoTT per minute by longer journeys is higher as by shorter journeys. It is assumed that this difference can be explained by the difference in relative and objective time changes. The fact that time savings of the same percentage for short distance travel is smaller than for long distance travel, and therefore smaller time savings are valued lower.

With the implementation of the VoTT into SCBA's can be concluded that only two of the reviewed countries does not use a constant VoTT for non- commercial small time savings, Germany and Canada. Germany uses 70% of the VoTT beneath a certain time threshold, and Canada does not calculate the travel benefits for time changes below 5 minutes. The Canada approach does not get much support, because in their view the sum of multiple small time changes is still worthless.

The final conclusion is that there is a good possibility that small time changes are worth less value, but that the current VoTT studies use SP surveys that are not capable to determine the value of small time changes. The German and Canadian approach show that it is possible to implement this into SCBA's. So if a good SP research is designed which is capable to determine the value of small time changes, the results of that research can be tested in an SCBA.

4.3 SECOND POSSIBLE IMPROVEMENT: TIME GAINS AND LOSSES

During this paragraph a literature review on the second possible improvement of chapter 3 will be described. The second possible improvement was the possibility of a different valuation between time savings and time losses. Hereby is meant the a difference in valuation of increased or decreased travel time thanks to the infrastructure projects. Travel time losses due to congested traffic is not covered by this difference in valuation. This aspect of time loss is already covered with the reliability of time. An example of a project whereby the travel time decreases can be a project whereby they lower the maximum speed limit to decrease the noise limit.

This possible improvement follows from the fact that the in the Dutch VoTT research it became clear that the willingness to accept for time losses was higher as the willingness to pay for time savings. Despite this finding the Dutch report still recommends a constant time value which is independent of savings or losses.

To investigate whether this is a good choice by the Dutch research, shall this subject be further investigated. During this paragraph will be examined whether or not foreign VoTT studies find different valuations for time savings/losses and what these studies recommend on this subject. Furthermore will be examined what general literature suggest on the subject.

4.3.1 WHAT DO FOREIGN VoTT STUDIES SAY ABOUT TIME GAINS AND LOSSES?

During the review of the foreign VoTT studies it became clear that the VoTT studies of Switzerland and the US did not pay attention to this subject. Therefore these VoTT studies are not implemented in this report.

DENMARK

The first SP experiment of Denmark presented four types of choices to the respondents. These four types of choices included the willingness to pay and the willingness to accept, which made it possible to investigate the difference in valuation of travel time savings and losses.

For the estimation of this valuation the Danish report describes a simply model formulation from De Borger and Fosgerau (2006 in (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a)). This model formulation is based on the prospect theory instead than the conventional utility theory.

The prospect theory explains what commonly is known as the willingness to pay - willingness to accept cap. Hereby the fact is that willingness to pay for a good is often much smaller valued than the compensation needed to the accept the losing of a good (Kaa, 2005). According to the prospect theory respondents make their choices based on the perceived values of time and costs, instead of the actual values of time and costs. The perceived values are dependent on a reference situation. The relation between the perceived values and the actual values is given by a so-called 'value function', figure 6 shows a possible value function.

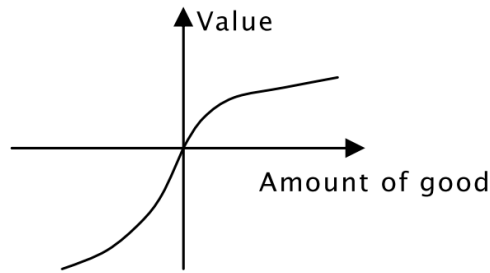


FIGURE 6, EXAMPLE OF A VALUE FUNCTION

The data shows that the willingness to pay for time savings is lower than the willingness to accept for time losses, which indicates the phenomenon loss aversion¹. This effect will be controlled when estimating the mean VoTT, using the model described above. Resulting that for a given value of $v = \frac{|\Delta costs|}{|\Delta time|}$ the perceived value is higher for the willingness to pay than for the willingness to accept.

It can be concluded that the Danish report take the difference between time savings and losses into account, but by controlling the 'loss aversion' effect they recommend a constant VoTT which is independent on the sign of the travel time change.

UNITED KINGDOM

The data of the original 1994 VoTT study produced by The Hague Consultancy Group showed that for any level of variation around the original journey time, the time savings are valued lower than the time losses. Despite these findings, the The Hague Consultancy Group did not recommend that the VoTT for the SCBA should be different for the sign of the travel time change. The report of Mackie (2003) re-analysed the data of the original 1994 VoTT study to give new insights on the original findings and recommendation.

In paragraph 4.1 is described that the original 1994 VoTT study used four types of options in their SP research, all these four options are related to one of the quadrants in figure 7:

- Quadrant 1: A choice between an option which was slower than the current journey and an option which was more expensive, all other things equal;
- Quadrant 2: A choice between an option reflecting the current situation and an option which was slower but cheaper than the current situation;
- Quadrant 3: A choice between an option which was faster than the current journey and an option which was cheaper, all other things equal;
- Quadrant 4: A choice between an option reflecting the current situation and an option which was faster but more expensive than the current situation.

¹ Loss aversion indicates that people show more aversion to loss of some consumption item than they show a desire for an equivalent amount of gain (Kahneman et al., 1990 in (Small, 2012))

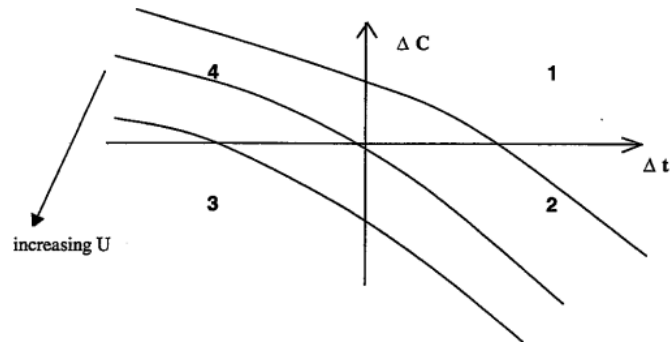


FIGURE 7, 4 QUADRANTS

During the re-analyses it was possible to calculate the implied variation in VoTT for each quadrant, because each combination of positive and negative values of Δ time and Δ costs implies in each quadrant. The results of this calculation is given in table 14.

TABLE 14, RE-ANALYSES OF THE HAGEU CONSULTANCY GROUP DATA (1994 PENCE PER MINUTE) (MACKIE, FOWKES, WHELAN, & NELLTHORP, 2003)

	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Business	9.01	21.80	11.52	4.76
Commuting	4.63	11.59	3.75	1.50
Other	4.55	11.18	3.29	1.34

Of the results in table 14 it becomes clear that the values in quadrant 1 and 3 are broadly similar and that there is a huge difference between the values of quadrant 2 and 4. This huge difference in values between quadrant 2 and 4 support the conclusion of The Hague Consultancy Group that losses are higher valued as savings, still Mackie et al (2003) have their doubts about the validity of this interpretation. They state that the small difference between quadrant 1 & 3 and huge difference between quadrant 2 & 4 can be dedicate to the "inertia" effect.

The inertia effect is a systematic preference for the current situation. In this case the choice options for quadrant 2 & 4 directly are referring to a reference journey (made by the respondent). The inertia effect would therefore provide that values of time in quadrant 2 will inflate thanks to the inertia effect which states that the respondents are less prepared to suffer a time loss in return for a cost saving. In quadrant 4 the inertia effect provides the opposite effect. If the results were analysed and an inertia term was introduced into the estimated utility functions for the data of quadrants 2 and 4, no significant difference between time savings and losses would be remain.

Thanks to all the aspects described above, the conclusion of the British VoTT report is that they do not believe that there is any empirical basis for distinguishing gains and losses. Therefore they recommend a constant unit value with respect to the difference in time savings and losses.

NORWAY

The Norwegian SP design was designed to provide an identification for different factors. One of these factors is the symmetry in value of time savings and losses. The report pointed out that economic theory suggests that the willingness to accept must be larger than the willingness to pay. They also state that there is different empirical evidence that confirms that time losses are higher valuated than time savings. To find this effect out for Norway itself they include willingness to pay and willingness accept options in their transfer price technique.

The results of the transfer price study shows that the willingness to accept for travel time losses is higher than the willingness to pay for a decrease in travel time (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997). The founded difference in willingness to pay for travel time savings and willingness to accept for travel time losses only is significant for inter-urban travel. Another interesting aspect they found is that the difference between the willingness to accept and willingness to pay increase by the income and travel distance.

Despite the founded difference the report recommends the same lognormal function distribution of the VoTT for time savings or losses. So there is no difference in value of time concerning time savings and time losses.

SWEDEN

In the national Swedish VoTT study did take the difference in time savings and losses into account. Choices representing time savings and time losses were equally often presented in the SP survey in order get information on the value of time savings and time losses.

The results of the SP survey the study does not mention anything about difference in valuation of time savings or time losses in relation to car drivers. Time losses (delay time) was dealt for long distance trains only. For that category the study found a relative value with respect to the in vehicle time of approximately 1.5 times the normal VoTT (Algers, Dillén, consultancy, & Widlert, 1996). What means that the willingness to accept for a certain time lose is one and a half times as large as the willingness to pay for the same amount of time gain.

As describe above, for car drivers noting was mentioned different another value for time savings or time losses. Therefore the report does not recommending a different valuation for travel time savings or travel time losses concerning car drivers. Also the report does not mention any recommendation for further research concerning this subject.

4.3.2 GENERAL INFORMATION ABOUT TIME SAVINGS AND LOSSES

Out of the previous paragraph can be concluded that all the reviewed foreign VoTT studies do not recommend a variable VoTT key-figure for the difference in time losses or savings. This report want to give an overview of more general information regarding this subject beside the review of the six foreign countries. To see whether or not the Dutch and foreign VoTT studies made the correct recommendation.

In the paper of Small (2012) regarding the valuation of time in general, a whole chapter is dedicated to this subject. In that chapter is one interesting example whereby Hu et al. (2012) find significant lower differences between the willingness to pay for time savings and willingness to accept for time losses in their RP data than in their SP data. By this outcome the doubt is growing whether or not in real live time losses are valuate higher than time savings.

A report of Daly et al. (2011) confirms in their research that many VoTT studies - which used SP data - demonstrate that the willingness to pay for savings often is lower valuated than the willingness to accept for time losses. They also confirm that all the reviewed VoTT researches recommend a constant unit value, which is independent on the sign of the time change. The report shows that they doubt whether in real live time losses are valuated higher than time savings, as currently is concluded in the various SP researches.

A general reason for this doubt, given by Daly et al. (2011), is that the difference in valuation is caused by a short term reasoning of the respondents. In the longer term, the opportunity to reschedule would decrease the inconvenience of a time loss and increase the value of a time saving, therefore the difference in valuation shall disappear.

Daly et al. (2011) state that it is almost impossible to indicate the real difference in valuation of time savings and losses by using SP surveys. Therefore they recommend that more RP surveys are needed to indicate whether or not there is a real difference in the valuation of time savings or time losses.

In a paper of Fowkes (2010) he refers to the fact that economists are predisposed by the Law of Diminishing Returns to expect that having more of something will have reducing value the more you already have. As example can be said that it is true that one would all dislike losing 100 Euros more than one would value gaining the same 100 Euros, starting from a given position. If, however, one were first to lose 100 Euros, one would surely value regaining those 100 Euros the same as the original loss. In this case one ended up at the same point he started. During travelling one losses and saves time most days, and it is silly to imagine that if one breaks even (so no all added together no time saving or lose during that day) one daily suffers a net loss of utility only because time losses are higher valued than savings. With that in mind Fowkes (2010) is in flavour for reversibility of VoTT.

4.3.3 CONCLUSIONS

In table 15 is shown how the different foreign VoTT studies deal with the difference in valuation of travel time savings and travel time losses. In the table is shown whether the VoTT study has adopt a difference in time saving and losses in their research design, whether there is a difference in results and whether or not they recommend another VoTT for travel time savings and travel time losses for commuting car drivers.

TABLE 15, OVERVIEW VOTT STUDIES FOREIGN COUNTRIES CONCERNING TRAVEL TIME SAVINGS AND LOSSES

VoTT study:	Adopted in research	Difference in results	Recommendation
Denmark	Yes	Yes	Constant unit value
United Kingdom	Yes	Yes	Constant unit value
Norway	Yes	Only for inter-urban trips	Constant unit value
Sweden	Yes	Only for long distance trains	Constant unit value
Switzerland	No	-	Constant unit value
United States	No	-	Constant unit value
Netherlands	Yes	Yes	Constant unit value

Out of table 15 can be seen that all of the reviewed foreign VoTT studies which adopted this subject in their research found different results in valuation between time savings and losses. Interesting to note is that by the VoTT researches of Norway and Sweden, which both made a distinguish between short vs. long travel distance, only a different valuation is found for the long travel distance. But despite these findings none of the reviewed foreign VoTT studies give a recommending for a VoTT key-figure which is dependent on the sign of the travel time change.

Also all the general literature studies give their preference for a constant unit value, which is independent on the sign of the travel time change. The general literature is asking itself whether loss aversion concerning travel time is a real issue in the real world. This question cannot be answered using data of a SP research, for the answer empirical data of more RP studies is necessary.

So both, the VoTT studies and the general literature, are in favour of the use of a constant VoTT key-figure. However some VoTT studies and general literature suggest that more research with RP data is needed for the edification of the existence of loss aversion of travel time. Unfortunately such a RP research is not feasible during this report.

4.4 THIRD POSSIBLE IMPROVEMENT: INCOME DEPENDENT VOTT

The last possible improvement what will be discussed during this chapter is the use of income dependent VoTT key-figures. Hereby is meant the difference in VoTT between different income classes and the use of that these different VoTT key-figures. Paragraph 3.3.3 provide some possible implementation methods for these income dependent VoTT key-figures in an SCBA.

In the Dutch research it became clear that respondents with higher incomes also had a higher VoTT and vice versa. During this paragraph will be examined whether or not foreign VoTT studies find different valuations per income class and what these studies recommend on this subject.

4.4.1 WHAT DO FOREIGN VoTT STUDIES SAY ABOUT INCOME DEPENDENT VoTT?

In the Dutch VoTT study it became clear that the estimated VoTT increased when the income of the respondents increased. Still in The Netherlands a constant income independent VoTT key-figure is used in the SCBA's. In this paragraph will be reviewed how the six foreign countries handle the relation of income and VoTT.

DENMARK

The Danish VoTT study state that according to both, theory and estimated models, the VoTT is dependent on income. Only the report concludes with recommendation of using a single average VoTT for an average kilometre of in-vehicle travel time, which is not dependent on income and travel mode.

As reason for this recommendation they state that not only the VoTT is dependent on income, but also the transport mode is dependent on income. Because people with different incomes tend to use different modes of transport. This effect will become clear in table 16 were the relation between income and VoTT per transport mode is given for the travel purpose 'commute'.

In the first column is shown the mean VoTT distribution (truncated at 1000 DKK and with 10 minutes time savings) without correction for income difference. One can see that the highest mean VoTT is found for car driving commuters and the lowest mean VoTT is found for bus driving commuters.

In the second column shows the weighted average after tax annual income for the same commute group. The highest average income is found by car driving commuters and the lowest average income by the bus driving commuters.

TABLE 16, RELATION OF TRANSPORT MODE AND INCOME IN DENMARK (FOSGERAU, HJORTH, & LYK-JENSEN, THE DANISH VALUE OF TIME STUDY, 2007A)

	Column 1	Column 2
Car driver	84	202,362
Car pass	54	169,436
Bus	34	156,027
Metro	82	195,814
S-train	37	186,353
Train	61	211,644

When the VoTT is dependent on the income and travel modes it can effect policy decisions. Hereby is meant that policy decisions will be more in flavour for car driving solutions, because they will generate more benefits than bus driving solutions. With other words this will lead to more decisions in flavour for the people with higher incomes. For that reason the Danish report recommend average kilometre of in-vehicle travel time, which is not dependent on income and travel mode.

UNITED KINGDOM

In the VoTT study of the UK a relation between the income of the respondents and the VoTT has been found. Due to these finding the report gives a recommendation for the use of income depend VoTT on three levels (Mackie, Fowkes, Whelan, & Nellthorp, 2003). These levels are:

- Level 1 Routine appraisal work: Small to medium sized projects, whereby only local effects are expected;
- Level 2 Major schemes and strategies: For bigger projects like major changes in the nation network of motorways. In these kind of projects the expected effects will have a larger and more spreader impact;
- Level 3 special applications like toll roads;

For the first level the report recommends a constant value of 6,6 Pence/min for the commuting group. So for this level the VoTT is not dependent of the income.

As recommendation for second level projects the report state that a more detailed variation of VoTT by income bands should be taken into account. The report describes three income bands and attached VoTT, which can be found in table 17.

TABLE 17 VOTT COMMUTING (MACKIE, FOWKES, WHELAN, & NELLTHORP, 2003)

Income band	VoTT commuting (pence/min)
Below 17.500 pa	3,6
17.500 – 35.000 pa	5,9
Above 35.000 pa	8,6

For level 3 appraisals such as the evaluation of toll roads, user charging schemes, metros and other 'user pays' facilities, the Department would rely on specific market research exercises. However, the report recommend that these be explicitly benchmarked against more general evidence, including the level 2 values above and other data from this study, and that they be subject to quality control.

The reason they choose for different approaches for different levels is that in smaller projects the effects are too small. Which causes that the benefits of a more exact SCBA is not worth the extra effort necessary for a more detailed analysis.

NORWAY

In this Norwegian VoTT is found that the VoTT increases with the income. Beside that they found that the relationship of VoTT and income is more explicit when individual income is used than household incomes. Yet another founding they made is that the increase of VoTT with income is higher for inter-urban travel than for urban travel. The last finding they did concerning income dependent VoTT is that the VoTT varies over the geographical regions in Norway thanks to the variation of VoTT by income. The last point is quid interesting for this research. In paragraph 3.3.3 was mentioned that the income of The Netherlands also varies over the geographical regions.

Despite all these findings the report does not recommend that an income dependent VoTT should be used in SCBA's (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997). They state that the income is already taken into account thanks to the different VoTT for different travel purposes.

SWEDEN

This study states that income is a potentially important source of variation for the VoTT. But they found that the relationship between income and VoTT is positive but fairly weak. This may come, because they used household income instead of an individual income. It is possible that it is influenced by gender - in general men have higher income and a higher VoTT - and most households consist out of a male and female. Therefore the VoTT -determined based on household incomes - is valued more moderate than based on individual income.

The report conclude with the recommendation that the VoTT key-figures are independent on the income. The state that the relation between income and VoTT is too weak to draw hard conclusions on that finding.

SWITZERLAND

In the Swiss report it is clear that the VoTT is income dependent, as can be seen in figure 8. They also found a connection between income categories and travel purposes. For example they found that business travellers on average has a higher income than leisure travellers and shopping travellers. Therefore they state that the income effect is already implied in the travel purposes.

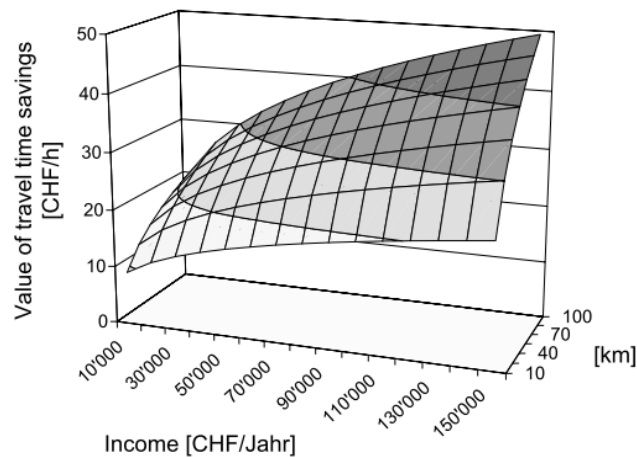


FIGURE 8 VOTT COMMUTING SWITZERLAND (AXHAUSEN, KÖNIG, ABAY, BATES, & BIERLAIRE, 2003)

They recommended VoTT key-figures which are independent on the income. They state that the difference in income is already covered in the different VoTT key-figures per transport purposes. So the Swiss VoTT research recommends the use of travel purpose (business, commute, shopping and leisure) VoTT key-figures instead of income dependent VoTT key-figures.

UNITED STATES

One of the main parts in their literature study is the relation between VoTT and income. They state that there is a connection between the income and VoTT. In the US the VoTT is directly connected to the income. Therefore one should expect that the VoTT is dependent of different income groups. This is however not the case, the VoTT only is dependent on the average US hourly income. The only further distribution they make is the distribution in business and private transport. Therefore the US VoTT study also prefer VoTT key-figures dependent on travel purpose instead of dependent on income groups.

4.4.2 CONCLUSIONS

In table 18 the main results of relation between VoTT and income of the VoTT studies of foreign countries is given. All the studies had noticed difference in results in VoTT when there were different income groups involved. In all the studies the VoTT increases if the income increased.

TABLE 18 OVERVIEW VOTT STUDIES CONCERNING INCOME DEPENDENCY

VoTT study:	Adopted in research:	Difference in results	Recommendation
Denmark	Yes	Yes	Constant value
United Kingdom	Yes	Yes	Different per level
Norway	Yes	Yes	Constant value
Sweden	Yes	Yes	Constant value
Switzerland	Yes	Yes	Constant value
United States	Yes	Yes	Constant value
Netherlands	Yes	Yes	Constant value

Still only one of the foreign VoTT recommend the use of income dependent VoTT key-figures in SCBA's. Two important arguments against the use of income dependent VoTT key-figures are:

- Income already covered in transport purposes;
- Use of income dependent key-figures will influence policy decisions in favour for high income transport modes.

In the Norwegian study an interesting finding was the connection between regions and income dependent VoTT. This was one of the possible improvements for the Dutch approach as mentioned in chapter 3. However the VoTT key-figures must be dependent on the income, travel mode and travel purpose to improve the use of VoTT in SCBA's. The current Dutch income dependent VoTT key-figures are not dependent on both travel purposes and travel modes. They only are dependent on the travel purpose or the travel mode. The use of these figures will not improve the accuracy of the travel time benefits.

A significant bigger SP experiment is needed in order to estimate VoTT key-figures which are dependent on all three aspect. The reliability of the results from SP experiments bigger than 12 choice sets is becoming lower (Louviere, Hensher, & Swait, 2000). A very big sample is than needed in order to restore the reliability of the research.

For this research it is not possible to find enough respondents for such a sample. Therefore this aspect will not be further investigated during this report.

4.5 MAIN CONCLUSIONS FROM THE REVIEW ON THE POSSIBLE IMPROVEMENTS

During this paragraph the possible improvements were analysed. The possible improvements are related to following subjects:

- Small time changes;
- Time savings and losses;
- Income dependent VoTT.

A review of six foreign VoTT studies and general literature has been used for this analysis. The main conclusions of this review are described below.

Small time savings: The literature is divided concerning this subject. All the foreign VoTT studies that has been reviewed suggest the use of a constant unit value which is independent on the size of the time saving. Even though all the VoTT studies that used a SP experiment founded a lower valuation for smaller time savings than for normal time savings. In addition to these finding most of the reports suggested that further research on this subject is needed.

During the review of the general literature it became clear that there are some countries that use a different valuation for small time savings. Also some general reports are in favour of a lower valuation for small time savings. However, this idea is rejected by other reports. Shortly summarised there is some discussion on this subject.

The reports that are in favour and some foreign VoTT studies provide some idea's and thoughts why the current SP experiments are not suitable for the valuation of small time savings. These points give some insights on which the SP design can be improved, so it is better suitable for the determination of the value of small time savings. Therefore is this subject further explored in the next chapter.

Time savings and losses: At this point the literature is the more straightforward. All the foreign VoTT studies reject a difference in valuation between time savings and losses. They also state that further research on this subject is not needed. However, some of the data of VoTT studies -which used SP experiments- showed a difference in valuation between losses and savings. This effect can be explained by economic effect of loss aversion. The VoTT studies reject this effect, because on the long term it would disappear or because people are more likely to choose for the reference alternative in SP surveys.

The general literature also is not in favour for a different valuation of time savings and losses. One research states that the difference in valuation using a RP study was significant lower than using a SP experiment. Also the other literature suggested that this effect must be measured using RP analysis. For this master thesis it was not possible to exam a RP study, so therefore this point will not be further explored in the next chapter.

Income dependent VoTT: At this point most of the foreign VoTT studies reject a income dependent VoTT, despite the fact that they all find a relation between the monthly income and the VoTT. Some of the reports state that the income dependency is adopted into the different categories of travel purposes and modes. Others state that huge infrastructure projects affect all income groups and therefore a average VoTT can be used.

To really use an income dependent VoTT in SCBA one must determine a VoTT which is dependent on the income, on the travel purpose and on the travel mode. To do so a very huge questionnaire is needed to draw significant conclusions. A disadvantage by very big questionnaires is that the reliability of the output becomes lower. In order to compensate for that effect a very large sample is needed. Such sampling is not possible in this study. Therefore this point will not be further elaborated in the next chapter.

5 PHASE C: DETERMINE THE VOTT OF SMALL TIME SAVINGS

In the previous chapter it became clear that a debate is still going on whether or not small time changes should be valued differently than bigger time changes. In most of the invested countries there is a policy to use time constant VoTT key-figure to determine the travel time benefits. A constant VoTT key-figure is used because results from other type of SP analyses were stood unreliable. Therefore during this chapter a redesigned SP experiment will be performed in order to provide more accurate VoTT key-figures for small time savings than with the current Dutch VoTT research.

5.1 RESEARCH DESIGN VOTT SMALL TIME SAVINGS

Chapter 3 showed that the current Dutch SP experiment is not suitable for the determination of the VoTT of small time savings. The foreign VoTT studies and general papers which were reviewed in chapter 4 provide some improvements for the determination of small time savings with the use of SP experiments. With these improvements it is possible to design a more suitable SP survey for small time savings. The main recommendations found in chapter four are:

- Using respondents with short distance travels. The Norwegian study suggest that people are more interested in absolute time savings instead of relative time savings (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997). In combination with the suggestion that people with smaller travel times will better notice smaller savings is it plausible that using respondents with short travel distance give different results;
- Using smaller time constraints in the SP experiment. In the current Dutch SP experiment the smallest time constraint was 5 and 10 minutes. By using that time period it is impossible to estimate the effects on smaller time savings. Therefore smaller time constraints in the SP experiment can lead to more plausible results;
- Using SP questions reflecting to commute. Multiple VoTT researches state that by using a unique reference trip respondents only consider the short term effects of travel time savings (Bates & Whelan, 2001). To let them consider the long-term effects it is better to refer the respondents with a trip they take more often, for instance commute journeys.

Other point which will make this research more suitable for the determination of small time savings will be discussed during the description of the research design.

5.1.1 RESEARCH DESIGN

A SP experiment is a sort of stated choice (SC) experiment. Within a SP experiment respondents must in choose their preferment situation based on the utility of the different presented choice options. There are multiple options to perform a SC experiment, which are suitable for a SP experiment. The book by Street and Burgess describes four possible SC experiment options (Street & Burgess, 2007). These options are:

- Binary response experiments: In this kind of experiment the respondents are shown a description of a good or service. Then the respondents were asked whether they could be interested in buying or using that good or service. So for each option they are shown the answer “yes” or “no”;
- Forced choice experiments: In a forced choice experiment, each respondents are shown a number of choice sets in turn. The respondents are asked to choose the best option from each choice set. There is no opportunity to avoid making a choice in each choice set;

- Forced choice experiments with a “none option”: Sometimes in choice experiments it does not make sense to choose one of the options. Therefore some choice experiments include an option like “no choice” or “none of these” or “delay choice”;
- Forced choice experiment with a common base option: Some choice experiments have a common option in each choice set, together with one or more options. This is often done so that the current situation can be compared to other possibilities.

In this research is chosen for the “forced choice experiment”. A forced choice experiment is the most suitable experiment because respondents should make a trade off between costs and time savings. This is not possible with binary response experiments. The common base experiment is not suitable, because in the common base experiment a reference journey is included. One of the recommendations was to avoid a unique reference journey in the SP experiment. In a forced choice experiment respondents must choose between two or more options. By changing the values of the options in the several questions it is possible to calculate the amount of money the respondent is willing to pay for less travel time. The “none option” is not suitable for this research, because there is a chance respondents will use that option too often (Street & Burgess, 2007). Therefore there is a chance that the results are not reliable for further analyses.

There are a number of terms which are used in SP experiments which will be briefly clarified. An SC experiment is performed according to a design. A design consists of a number of choice situations, each choice situation with two or more choice options. The respondent must pick one of the choice options in each choice situation. In this research the choice options will be different commute journeys. These choice options are described by resistance factors. In a SC experiment these resistance factors are called “attributes”. Each attribute can take various values. In a SC experiment these various values are called “levels” and are predetermined. So briefly summarised, a SC design describes all the possible choice situations which can be submitted to the respondent. In most cases a design contains too many choice situations for a respondent. For that reason the choice situations are divided into several parts. These parts are also known as choice sets. Each respondent is shown one choice set. In the figure below the terms are shown.

Block	Choice situation	Option 1		Option 2		Attributes
		Travel time	Travel costs	Travel time	Travel costs	
1	1	0	0,2	-3	0,7	Level
1	2	-5	1,2	-3	0,2	
1	3	-3	0,7	-5	1,2	Choice option
1	4	0	0	-3	0,7	
1	5	-5	1,2	-3	0,2	Choice situation
1	6	0	0,7	-3	1,3	
2	7	0	0	-3	0,2	Choice set
2	8	0	0	-3	1,2	
2	9	-5	1,2	0	1,2	
2	10	-5	1,2	0	0,7	
2	11	-5	0,7	0	0	
2	12	-3	0,2	-5	0,7	

FIGURE 9, IMPORTANT TERMS OF A SP EXPERIMENT

Several steps should be followed to design and perform an SC experiment. The book “stated choice methods; analysis and application” mentioned seven steps that are usually followed (Louviere, Hensher, & Swait, 2000). These seven steps are:

- Defining the research objective;

- Perform a supporting qualitative study;
- Develop and test the choice experiment;
- Define sample characteristics;
- Perform data collection;
- Perform model estimations;
- Perform policy analysis.

The research objective is to determine the valuation of small time savings. This research focuses only on commute travel by car.

5.1.2 DEFINE ATTRIBUTES AND LEVELS

This paragraph defines the attributes and levels of the choice situations. Next the attributes will be defined. For the commuting journey - from the living area to work and vice versa - there are two main factors which influence the journey. These are the “travel time” of the journey and the “travel costs” of the journey. These two factors will form the attributes used in this survey.

When the attributes are known, the levels per attribute can be defined. Too many levels causes indistinctness what can influence the reliability of the choices made by the respondent. Contrast a shortage of levels creates a lower quality. An attribute with only two levels can only give a linear description of the attribute function. While more levels also give descriptions about non-linearity. In this research is chosen for three levels for the attribute “travel time” and four levels for the attribute “travel costs”. In the subparagraphs below these two attributes and their levels will be described in more detail.

Travel time:

In this survey the travel time means; the travel time of the commute journey of the respondent. The first level of this attribute is determined by an estimation of the respondent. The respondent estimates his or her average travel time for his or her commute journeys. By average is meant his or her normal journey time excluding of extraordinary situations such as accidents.

The reason for taken an average travel time instead of one specific commute journey is to force more people to consider the long-term effects. Bates and Whelan conclude in their paper that it is difficult to invest the valuation of small time changes by SP surveys, because these SP surveys refer to a certain specific journey. Therefore the respondents are more willing to consider only the short-term effects (Bates & Whelan, 2001). A report of Rose et al. stated that not referring to an existing situation causes a negative effect on the effectiveness of the study, because the respondents are less able to distinguish the choice options (Rose, Bliemer, Hensher, & Collins, 2007). So to satisfy both recommendation will be asked about the average time of an all day trip.

The other two levels are dependent of the first level. The second level is a travel which is 3 minutes shorter as the first level, and the third level is 5 minutes shorter as the first level. There is chosen for 3 and 5 minutes for two reasons. The first reason is that the lowest time option in the previous Dutch VoTT research was 5 minutes and in this research the goal is to determine the value below 5 minutes. The second reason is that the respondents still have to make a distinction between the choice options. There should be some notable difference between the levels.

A selection is made on bases of travel distance to make sure that the respondents are able to notice a travel time saving of 3 or 5 minutes. Only people who live in a range of 25 km of their working place are invited for the survey.

TABLE 19, ATTRIBUTE TRAVEL TIME

Travel time:		
respondents estimation of the total travel time	3 minutes shorter as the first level	5 minutes shorter as the first level

Travel costs:

The second attribute used in this research is the travel costs. By travel costs is meant the average costs incurred by the respondent for his or her living / work trip. These costs exists among other things out of fuel costs, depreciation and the willingness to pay for the time spend.

The first level of this attribute is again determined by an estimation of the respondent. In this case the respondent estimates his or her average travel costs for his or her commute journey. By average travel costs is meant the normal costs for his or her commute journey excluding extraordinary situations.

The other levels are all more expensive and depended on the first level. Reason why the other levels are more expensive is because the research intent to show the respondents willingness to pay for a shorter travel time. In general are people prepared to pay more in order to travel faster (Fowkes, 2010). The other way around applies that people which are travelling slower will generally pay less for their journey. This is based on the saying 'time is money'.

The exact specification of the levels is based on the current VoTT key-figure for commuting car drivers. The current VoTT key-figure for commuting car drivers is € 9,71 which equates to € 0,49 per 3 minutes and € 0,81 every 5 minutes. The three values that are used in the survey are; the lowest is 50 % of € 0,49, the highest is 150 % of € 0,81 and the last one is in the middle of the two extremes. All values are rounded to the nearest 10 cents. So the second level will be € 0.20 more expensive as the first level, the third level will be € 0.70 more expensive as the first level and the final level will be € 1.20 more expensive as the first level.

TABLE 20, ATTRIBUTE TRAVEL COSTS

Travel costs:				
respondents estimation of the total travel costs	€ 0.20 more expensive as the first level	€ 0.70 more expensive as the first level	€ 1.20 more expensive as the first level	

After setting the choice situations the experiment designs and choice experiments will be developed. From these designs and choice experiments follow the choice sets for the respondent. Which will result in the questionnaire for the research.

5.1.3 DEFINE NUMBER OF CHOICE SITUATIONS

The design of this experiment is based on a 'factorial design'. In a factorial design one can compare the effects of two or more treatments on some response variable (Street & Burgess, 2007). In a factorial design there are two options, a full factorial design and a fractional factorial design. In a full factorial design each of the possible level combinations appears at least once. An estimation of all the different effects of the attributes can be made with the combinations of a full factorial design. The book of Street and Burgess speaks about three different effects:

- Main effects: This is the effect of a factor, independent of any other factor, on the response;
- Orthogonal polynomial contrasts: Orthogonal contrasts are a set of contrast in which , for any distinct pair, the sum of the cross-product of the coefficient is zero. Polynomial contrast are a special set of orthogonal contrasts that test polynomial patterns in data with more than two means;
- Interaction effects: Two factors are said to interact if the effect of one of the factors on the response depends on the level of the other factor.

In a fractional factorial design only a subset of level combinations appears. Due the reduction of choice situation a fractional factorial design mainly estimates the main effects. The fractional factorial design is often used when the number of treated combinations in a full factorial design is too large.

The number of treated combinations is calculated in the following way. Suppose that there are k attributes and that each of the attributes has an l amount of levels. Then the number L of combinations is: $L = l^k$

In this research there are $3^1 \times 4^1 = 12$ treated combinations possible. This is not a large number of treated combinations, so the full factorial design of 12 treated combinations will be used.

The design is based on 12 choice options (the 12 treated combinations). With those 12 choice options is it possible to generate choice situations. In this research each choice situation will contain a number of choice options. Suppose that the amount of choice options is m . In this research the number of choice options per choice situation is $m=2$. In this research every choice situation occurs only once, also called unique choice situations. The number of choice situations can be calculated by $\binom{L}{m}$. Resulting in $\binom{12}{2} = 66$ unique choice situations.

Not all of these 66 choice situations are usable, because these 66 choice situations contain some dominant options. The dominant options is for the respondent obvious better than the other option in a choice situation. An example is: options shorter travel time with lower cost, option two longer travel time with higher costs. In this example are the attribute levels of option one obvious better for the respondent than option two. There are 18 choice situations left after removing all the dominant choices from the 66 unique choice situations (see appendix II).

In most surveys is the number of choice situations per respondent ranging between 1 and 16 choice situations, with an average of 8 (Louviere, Hensher, & Swait, 2000). Eighteen choice situations are too many for a choice set. The risk that respondents do not take the test seriously and quit during the questionnaire increases. To tackle that problem the 18 choice situations are complete mixed and afterwards split into two choice sets both containing 9 choice situations (see appendix II).

In both choice sets one 'check' choice situation is added. This check is done by giving the respondents a dominant choice situation. By adding this dominant choice situation it is possible to check whether or not the respondents understand the SC task. So that in the further analyses the unreliable SC responses could be withdrawn from future analyses.

The respondents get one choice situation at a time. In figure 10 is one example of choice situations shown. Before the SC experiment the respondents must fill in a questionnaire about their normal living/work journey. In this questionnaire questions are asked about their travel purpose, for example about travel distance and travel comfort. The complete questionnaire including the purpose of the questions is attached in the annex (See appendix III).

O Option A	O Option B
Travel time is the same as the current situation	Travel time is 3 minutes shorter as the current situation
Travel costs are the same as the current situation	Travel costs €0,20 more expensive as the current situation

FIGURE 10, EXAMPLE OF A CHOICE SITUATION

A pilot is done in order to improve the questionnaire and SC experiment, before the questionnaire and SC experiment is sent to the respondents. Three employees of W+B, have given their opinion about the questionnaire and SC experiment. Thirty employees of Bruins & Kwast filled in the questionnaire and SC experiment to see if the questionnaire is complete and is running smoothly.

5.1.4 DEFINE SAMPLE

In the next part the sample characteristics will be defined. The previous Dutch SP research of 1998 gathered information for all the different travel purposes. This smaller research shall only focus on the travel purpose “commute” (travellers from home to work and vice versa). For that reason it is possible to conduct the research among the employees of W+B. For a good sample it is of importance to take all the important aspects into account. The following aspects are taken into account in this research:

- *Travel purpose*: Travellers with different purposes value their time differently. Generally, for example, business travel is valued higher than private trips to the beach. This survey will only focus on the travel purpose “commute”, as was described in the introduction of this paragraph;
- *Travel distance/time*: The study population have a maximum of 25 km travel distance from their home to work. The reason for this selection is that respondents with lower travel time and travel distance are able to better distinguishing small travel time changes. This reason causes a discussion. Because by selection only respondents with a maximum of 25 km the total travel time will not be very large and therefore small time changes are relative large for this group. However, referring to the studies from Sweden, Switzerland and Norway, it appears that relative travel time savings is of minor importance than the absolute time savings (Axhausen, König, Abay, Bates, & Bierlaire, 2003) (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997).
- *Travel mode*: The travellers with different travel modes value their time differently. These different valuations for travel options arises from the difference in travel comfort. This research will only focus on the travel mode “car”.
- *Travel comfort*: During a car journey, one can experience different travel conditions. Think for example whether one experience traffic jams during the trip. Also the presence of certain devices, such as car kits, or the presence of other people may affect the comfort of the trip. In addition can be assumed that the more comfort one experience the less objections people have against the travel time. Which might causes that travel time savings are undervalued. For this reason it is important to know how people spend their travel time in addition to the movement itself, and if they experience any traffic jams during their journey.
- *Travel costs*: Travel costs have influence on how people value the travel time. In some cases people get their travel costs partially or fully reimbursed. There is a chance that these people are not capable to estimate the travel properly and therefore value the travel time lower than people who do pay their own travel costs. Therefore, it is important to get an overview of the categories of respondents that pay their own travel costs or those that get the travel costs partially or fully reimbursed.
- *Income*: From previous VoTT studies is known that VoTT is dependent on the income of the respondents. Respondents with higher incomes will value the travel time higher as respondents with

significant lower income. As already described this research is carried out among the staff of W+B only. Since respondents do not like answer questions about their income, there is the possibility that not enough usable results will be collected. For that reason is there no question concerning the income of the respondents. Instead there will be assumed that the salary of all respondents is the average salary of W+B. Which is currently €3.060 per month.

- *Location:* Most of the respondents, 65%, live and work in the East of The Netherlands, because the headquarters of W+B is established in Deventer. The second largest group is working and living in the Randstad area, 20% of the respondents. 9% Of the respondent live and work in the South of The Netherlands and finally 3% is working and living in both the North as in the Middle of The Netherlands.
- *Sex:* In the Dutch VoTT research is found that female travellers, with travel mode “business” and “other”, are less time sensitive than male travellers. Therefore the female travellers will value the travel time lower than male travellers. For the travel mode “commute” the research does not mention a difference between sexes. The Dutch research from 1997 and it is possible that over time these conclusions have changed. For that reason a question referring the sex of the respondents is added.
- *Age:* From different studies is known that the age of the respondents has effect on the VoTT. From the Dutch VoTT study is known that younger business travellers are more time sensitive than older business travellers. The younger business travellers will value the travel time higher. For the travel mode “commute” the 1997 research does not mention a difference between ages. However, it is possible that over time these conclusions have changed. For that reason a question referring the age of the respondents is added.

The net size of a sample depends on the amount of groups within the aspects on which significant statements must be made. In this experiment the aspects “travel purpose” and “travel mode” are the most important. For both aspects this report will research one group, these are respectively “commute” and “car”. Approximately there 75 respondents are needed to make significant statements about these groups.

5.1.5 DEFINE DATA SELECTION

This data collections contain three aspects. The first how to recruit the respondents. Second the connection of the respondent and the survey instrument, and third the way the response data is collected.

The respondents of the survey are employees of W+B. In total the company W+B has over 800 employees. For this research are only respondents with a maximum living/work journey distance of 25 km needed. Therefore in total 481 employees of W+B will be approach for participation in the survey. The goal is to receive 75 of more usable completed surveys. More than 75 usable respondents will have a positive effect on the reliability of the survey.

The respondents will receive an email with an invitation to fill in the online survey. An online survey has some advantages. It is efficient, less costs , it is quick and the results directly are digital available. The online program “ThesisTools” is used to construct the online survey (Thesistools, 2013).

As said the response data is directly digital available after the respondents filled in the survey. With the program ThesisTools it is possible to collect the data in an Excel format.

5.2 RESULTS OF THE SMALL TIME SAVING VOTT RESEARCH

This paragraph will describe more about the results from the SP experiment. First some general information about the questionnaire will be mentioned. Second the main results concerning the valuation of small time savings are described, and third some other results concerning the valuation of small time savings will be discussed.

Within three weeks after the release of the survey 211 people returned the their survey. Of these 211 returned questionnaire where 187 questionnaires completely filled in. The SP experiment part includes a test question, to exclude respondent who did not performed the SP experiment correct. In total 11 respondents had given the wrong answer at this test question. So in total there are 176 complete and usable surveys available.

For this research to the VoTT of small time savings the focus is only on car drivers. The respondents which filled in the survey had al kind of different transport modes, like walking, biking, bus/tram, train and car. The distribution of the respondents per transport modes is the following:

TABLE 21, DISTRIBUTION OF RESPONDENTS PER TRANSPORT MODE

Transport mode	Amount of respondents	Percentage of respondents
Walk	9	5%
Bike	64	39%
Bus/Tram	8	5%
Train	26	16%
Car	59	36%

In total 59 complete usable surveys are used for the determination of the value of small time savings. With use of the questionnaire which was added to the survey some characteristics of the sample are divined. The main characteristics of the car driving group are:

- Gender: The group existed out of almost twice the amount of male instead of female;
- Travel time: For the living/working journey 4 of the 10 spend less than 20 minutes on travel time and almost 6 of the 10 spend more than 20 minutes;
- Travel cost reimbursement: Most of the respondents get their travel cost (partly) compensated or split the cost among his fellow passengers. 1/5th of the respondents is personally responsible for the travel costs;
- Travel time use: Almost 50% of the respondents uses their travel time for other activities (phone calls, eating, etcetera) among travelling;
- Divining useful time saving: On the question what the respondents would suggest to be a useful amount of travel time saving 75% of the respondents suggest 5 or 10 minutes. Still almost 2 of the 10 respondents state that every minute could be useful.

The exact amount of absolute and relative figures of these characteristics can be found in appendix IV. In this appendix are also the other characteristics of the survey group divided.

The other part of the survey, the SP experiment, provides the necessary input for the estimation of the VoTT for small time savings. By asking the respondents to choose between two alternatives which are dependent on travel time and travel costs it is possible to estimate the unknown parameters (constant, β_{costs} and β_{time}) in the utility function:

$$V_{i\alpha} = constant + \beta_{costs}Costs + \beta_{time}Time$$

This estimation is performed using the BIOGEME software. This software need the data from the SP experiment and a model design as input to estimate the parameters. In the model is described the function and which parameters must be estimated. The input for the main estimation can be found in appendix V. The programme BIOGEME will estimate the parameters using the multinomial logit model. An explanation of the estimation process is given in appendix VI.

With use of the software the following parameters were found by the group of 59 car driving respondents:

TABLE 22, MAIN RESULTS PARAMETERS BIOGEME

Parameter	Value
β_{costs}	-4.03
β_{time}	-0.25

The total format of parameters and other outputs of the programme BIOGEME can be found in appendix VII. The value of the parameter 'constant' was too small and therefore not significant for the utility function. For that reason the parameter 'constant' has been removed from the utility function. The results also show that the parameters β_{costs} and β_{time} are dependent on each other. This dependency makes it possible to calculate the VoTT for small time savings. The VoTT per minute for small time savings can be calculated by:

$$VoTT \text{ small time savings} = \frac{\beta_{time}}{\beta_{costs}}$$

This results that this group of 59 car drivers valued small time savings on €0,06 per minute. Multiplying this results times 60 shows that small time savings are valued at €3,76 per hour. In table 23 is shown the VoTT for small time savings and the current Dutch VoTT.

TABLE 23, CURRENT DUTCH VOTT VS VOTT SMALL TIME SAVINGS

	VoTT per minute	VoTT per hour
VoTT Small time savings	€0,06	€3,76
Current Dutch VoTT	€0,15	€9,71

Beside the main VoTT of small time savings for car drivers some more aspects are estimated. This is done to analyse whether there is a difference in the valuation of small time savings between car drivers who:

- Gets their living/working journey compensated or not;
- Spend their travel time on other aspects as travelling or not;
- Spend more time than 20 minutes for their living/working journey or less than 20 minutes.

Beside these three differences it was also the plan to estimate the difference in valuation between sexes. But because of the low number of female respondents the results were unreliable to use.

The other analyses shows the following results (for more information on the results, see the BIOGEME output in appendix VII):

TABLE 24, DIFFERENCE IN TRAVEL COST COMPENSATED VOTT SMALL TIME SAVINGS

	VoTT per minute	VoTT per hour
Respondents who gets their travel costs (partly) compensated	€0,08	€4,51
Respondents who does not get their travel costs compensated	€0,01	€0,30

Respondents who gets their travel costs (partly) compensate, value the travel time higher than people who does not get any compensation for her travel costs. This difference in valuation can be explained by the fact that it is plausible that people who gets their journey compensated are more likely choose for more time savings despite the costs.

The extreme low VoTT for the respondents who did not get a compensation for their travel costs can be explained by the fact that this number of respondents was very low.

TABLE 25, DIFFERENCE IN TASKS VOTT SMALL TIME SAVINGS

	VoTT per minute	VoTT per hour
Respondents who use their travel time for other tasks	€0,03	€1,92
Respondents who use their travel time only for travelling	€0,09	€5,50

Respondents who does not use their travel time on other activities value their travel time higher than the group who uses their travel time on other activities. This difference in valuation can be explained by the fact that it is plausible that respondents who can work or eat during their journey are more likely choose for more costs savings despite the time. Because they use their time for multiple tasks and therefore use their travel time more useful than respondents who only use their time for travelling. Which results in a higher valuation for the utility of time instead of costs.

TABLE 26, DIFFERENCE IN TRAVEL TIME VOTT SMALL TIME SAVINGS

	VoTT per minute	VoTT per hour
Respondents who spend more than 20 minutes	€0,07	€3,18
Respondents who spend less than 20 minutes	€0,05	€4,02

These results are respectively close to each other. A possible explanation for this can be that relative time savings are less noticed than absolute time savings. This effect is supported by the findings and assumptions in the Norwegian VoTT study (Ramjerdi, Rand, Saetermo, & Saelensminde, 1997).

5.3 CONCLUSIONS

In most of the reviewed VoTT researches is found that smaller time savings are valued lower than bigger time savings. These findings were rejected thanks to unreliable SP designs. This SP experiment is better designed for small time savings. Because three main recommendations from the literature study are used to tackle the unreliable aspects of the SP experiment. These recommendations are:

- Using respondents with short distance travels;
- Using smaller time constraints in the SP experiment;
- Using SP questions reflecting to commute journeys.

The SP experiment is presented to a group of 481 respondents. These respondents are recruited within the company W+B. A disadvantage of this group is that it is not a perfect reflection of the Dutch society. The main differences between the respondents of the 2013 Dutch VoTT study and the respondents used for this research are:

TABLE 27, DIFFERENCE SAMPLE VS. AVERAGE DUTCH ROAD USERS

	Average Dutch road users ¹	Small time VoTT study ²
Average income	€2.353 per month	€3.060 per month
Average education level	25% high educated	70% high educated

After analysing the data of the respondents 59 useful complete questionnaires remain. With these useful questionnaires an estimation of the VoTT for small time savings is made. The estimation model is based on the multinomial non logit model. The outcomes of the model shows a significant lower VoTT than the current Dutch VoTT key-figures, see table 28:

TABLE 28, DIFFERENCE VOTT SMALL TIME SAVINGS VS. THE CURRENT VOTT

	VoTT per minute	VoTT per hour
Small time savings	€0,06	€3,76
Normal	€0,15	€9,71

It can be expected that this VoTT for small time savings is higher than if a more average group was taken. Because all the VoTT studies, the Dutch and the ones of foreign countries, show that the VoTT grows with the income and that higher educated people have a higher VoTT. However, this is only an assumption. To effectively explain this more research will be needed.

The effects of a lower VoTT for small time savings shall be further investigated during the next chapter, because there is a strong indication that small time savings should be valued lower.

An extra research was done to the bicycle VoTT, because there is currently no VoTT key-figure for that travel mode. Currently in SCBA's the VoTT key-figure of tram and bus is used for the calculation of time saving benefits for bicycle users. The group of bicycles was also around 60 respondents. The bicycle drivers valued the small travel time savings almost three times lower than the car drivers. The exact value they give to small time savings is €0,02 per minute, for the results of BIOGEME see appendix VII.

¹ Figures provided by CBS

² Figures provided by W+B

6 PHASE D: CASE STUDY

During this chapter the key-figures and methods found in the previous chapters will be tested in a case study. The goal of this case study is dual. The first goal is to check whether or not the described methods are suitable to use in an SCBA. The second goal is to check what the effect on the outcomes will be.

This chapter exists out of two phases; first the design of the case study will be defined. Second the results of the case study will be analysed.

6.1 CASE STUDY DESIGN

The case used in this case study is the implementation of a Dutch secondary road. The figures for this case study are the real numbers of that specific project, but due to the decision phase in which the project currently stays is decided to keep the project anonymous in this report (Witteveen+Bos, forthcoming).

The implementation of this road shall have a positive effect on the travel time in the surrounding area, because the project supplies a better/faster alternative in comparison to the existing road network. The traffic model shows that for commute car drivers 4076 hours are daily saved on travel time, thanks to the implementation of the project. The traffic model that is used in this report is based on an NRM model, beside the model they supplied an origin/destination matrix.

This total number of time saving is the sum of all individual time savings. These individual time savings can vary between a time saving of less than a minute and a time saving of more than twenty minutes. Therefore it is possible that there are many individuals with very small time savings or less individuals with significant high time savings. A more comprehensive traffic model is needed for this case study so that the travel time savings are known per category of time saving. Consequentially a model is generated in which the amount of hours travel time savings are divided into different categories, ranging from 0-1 minute runs to over 20 minutes. The results of this traffic model can be found in table 29. It was possible to divide the model into different categories of time saving because an origin/destination model was provided. However origin/destination models nowadays are estimated based historical data (Wikia, 2013). Therefore this data can be used as an indication, but it does not provide one hundred per cent accurate information. In the future, these models may be linked with navigation systems which allows them to provide more accurately estimations.

TABLE 29, TRAFFIC MODEL CASE STUDY, DAILY AMOUNT OF HOURS SAVED FOR TRAVEL MODE COMMUTE (WITTEVEEN+BOS, FORTHCOMING)

Time saving category	Hours of time saving	Time saving %	Cumulative
0-1 minutes	680	17%	17%
1-2 minutes	666	16%	33%
2-5 minutes	1157	28%	61%
5-10 minutes	833	20%	82%
10-20 minutes	612	15%	97%
>20 minutes	128	3%	100%
Total	4076		

The traffic model shows that in this project over 60% of the commuting time savings are within the categories smaller than 5 minutes. So it can doubt whether a calculation with a constant unit value provides a proper reflection of the travel time benefits, due to the big amount of small time savings. This is one of the reasons why this project was chosen for this case study.

This case study shall compare three methods for the calculation of the daily travel time benefits of the travel mode commute. In this case study is looked only at the travel mode commute, so it is possible to use the results of the previous chapter. Two of these methods will take the lower valuation of small travel time savings into account, as is determined in chapter 5. The three methods that will be tested are:

- Constant VoTT: This method is currently used in The Netherlands. In this method there is no distinction between small and normal travel time savings, all time savings benefits are calculated with the same VoTT as is graphically shown in figure 11. This method shall be used as reference;

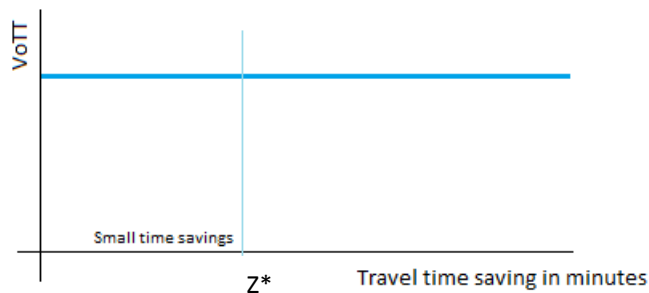


FIGURE 11, CONSTANT VOTT

- Step function: This method is also currently used in Canada and Germany. In this method the small time savings are valued with a lower VoTT than the normal time savings. This is graphically shown in figure 12;

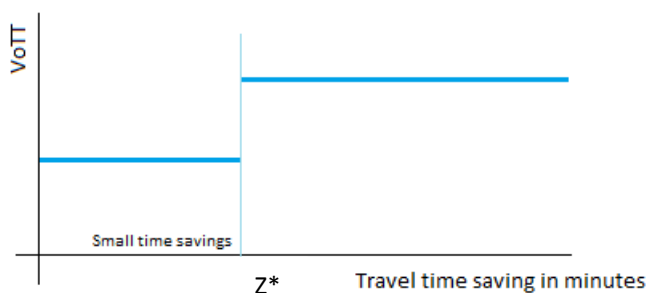


FIGURE 12, STEP FUNCTION

- General Linear Discounting (GLD) function: In this method the valuation of small time savings is growing linearly with the time saved. After a certain time threshold a normal VoTT is used, as can be seen in figure 13.

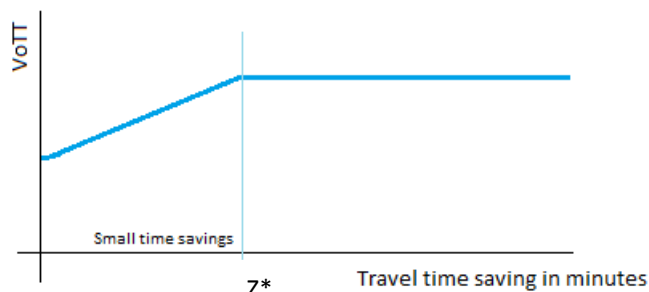


FIGURE 13, GENERAL LINEAR DISCOUNTING FUNCTION

There are two reasons for the selection of these three methods. The first reason is that these functions are all able to practically implement a VoTT key-figure for small time savings without the use of complicated formulas. This is of importance for the practical use of the SCBA. The second reason is that none of these functions starts

at zero. In paragraph 4.2 Fowkes (2010) stated that it is not correct that small time savings would be completely worthless.

During this case study a calculation will be made of the daily travel time benefits. The daily benefit will not be passed on the full life time of the project, because the parameters for that part of the calculation did not change. For the calculations of the daily travel time benefits is the following information needed:

- Threshold of small time saving, z^* : 5 minutes;
- VoTT for small time savings, $VoTT_{small}$: 3,76 euro/hour;
- VoTT for normal time savings, $VoTT_{normal}$: 9,71 euro/hour.

6.2 CASE STUDY RESULTS

In this paragraph the case study results will be discussed. The focus will be on two subjects during this discussion. The first subject is whether or not the methods are suitable to use in for the calculation of travel time benefits. The second subject is to review the outcomes of the different methods.

During the execution of the calculations it became clear that all the methods were suitable for the calculation of travel time benefits. For all three methods it is possible to design a spread sheet whereby the difference in execution duration between the various methods is nil.

The two methods which take small time savings into account need a more specified traffic model for the calculations. For the step function a traffic model considering travel time savings of less than 5 minutes and time savings starting from 5 minutes is needed. The GLD function need a traffic model whereby the time savings for less than 5 minutes are categorised per minute and all the time savings starting from 5 minutes. During the case it became clear that it is possible to generate these more subdivided traffic models using data from the origin/destination matrix. However, the subdivided traffic models have a greater deviation with respect to the normal models. This is because the subdivided models are based on origin/destination matrices which in turn are based on estimations of historical data. In the future, this deviation can be smaller, because then better origin / destination matrices based on information from navigation systems can be used.

By analyzing the outcomes of the calculations of the three different methods it became clear that using different valuation methods for small time savings results in significant different benefits. In table 30 the difference for the commute travel time saving benefits is shown as a percentage.

TABLE 30, OUTCOMES CASE STUDY

Method	Daily travel time benefit
Constant VoTT	100%
Step-function	62%
GLD	80%

From the results can be seen that the benefits using the step methods lies 1/3 lower than the current used method. Notice that the normal travel benefits, calculated in the SCBA, are around 190 million euro (Witteveen+Bos, forthcoming) so this is a significant difference. The impact of this method on the results of total SCBA will be decisive. Conform Fowkes (2010) is there a improved change of undervaluation of the travel time benefits, by calculation small time savings benefits using a constant lower VoTT. Therefore it is the question of this methods really shows more accurate results than the current method.

In the GLD function the VoTT per minute grows until z^* is reached. This effect that is also found in several VoTT studies (Fosgerau, Hjorth, & Lyk-Jensen, The Danish Value of Time Study, 2007a) (Mackie, Fowkes, Whelan, & Nellthorp, 2003). When using this method the travel time benefits for this case project will decrease with 20 per cent. This decrease of 20 per cent will have a significant impact on the outcome of the SCBA.

It is hard to recommend which method should be used. Therefore more research on the effects and VoTT is needed. Nevertheless both methods show significant differences in travel time benefits. These significant difference in travel time benefits could have massive impact on the results of SCBA's.

7 PHASE E: RECOMMENDATIONS & CONCLUSIONS

In the introduction was stated that currently a lot of road projects with significant high costs and low time savings are planned or constructed. Therefore was the aim of this master thesis to give a recommendation on the use of value of travel time in social cost benefit analyses. During this chapter the conclusions of this report are described.

This final chapter is divided in three parts. First the main research findings are briefly summarised. In the second part the strengths and limitations of the performed research are discussed. Finally implications for policy makers and researchers are described.

7.1 CONCLUSIONS

In order to answer this main objective four sub questions in order to answer the main research question was set. During this paragraph first the four sub questions will be answered.

What are possible improvements for the current Dutch value of travel time determination and the use of value of travel time in social cost benefit analyses?

The Dutch key figures set by Rijkswaterstaat, to calculate travel time benefits, are based on the results of a research in 1999 performed by the Hague consultancy group. Recently, in 2013, the value of travel time is revised by Significance. Both studies are based on stated preference experiments. Currently the value of travel time key figures used by Rijkswaterstaat are constant unit values. However considering the results of these studies these values are probably dependent on the following three factors:

- Small vs. bigger time savings;
- Time gains and losses;
- Income.

The results of the stated preference experiments shows that the valuation per minute decreases if the amount of saved travel time decrease. Also it shows that the value of travel time increases if the average household income increase. Finally the results show that willingness to pay for time savings is lower than the willingness to accept for time losses. Despite these findings the travel time benefits are calculated using a constant unit value, which is independent on the size and sign of the amount of time change. In addition the income dependent value of travel time key-figures are not used for the calculation of the travel time benefits. Even though this might belong to the possibilities.

What does other literature tell about the feasibility of these possible improvements?

To answer this question a literature study was done, considering six foreign value of travel time studies and general literature about the three subjects. The main conclusion is that, for this report, 'small time savings' is the only feasible possible subject for improvement. The conclusions vary per subject and are therefore defined below.

Small time savings: Discussion on the valuation of small time savings is ongoing. All the foreign value of travel time studies suggest the use of a constant unit value. Even though all the value of travel time studies -that used a stated preference experiment- founded a lower valuation for smaller time savings than for normal time savings. In addition almost all studies suggested that further research on this subject is needed. In contrast, some countries used a different method to determine the travel time benefits for small time savings.

During the review of the general literature it became clear that some reports are in favour of a lower value of travel time for small time savings, others rejected these ideas.

The reports that are in favour and some foreign value of travel time studies provide some idea's and thoughts why the current stated preference experiments are not suitable for the valuation of small time savings. These points give some insights on which the stated preference design can be improved so it is better suitable for the determination of the value of small time savings. Therefore is this subject further explored in this report.

Time savings and losses: At this point literature is more straightforward. All the foreign value of travel time studies reject a difference in valuation between time savings and losses. They also state that further research on this subject is unnecessary. However, some results of value of travel time studies which used stated preference experiments showed a different valuation between losses and savings. This effect can be explained by economic effect of loss aversion. The value of travel time studies reject this effect, because on the long term it would disappear or because people are more likely to choose for the reference alternative in SP surveys.

In addition general literature is not in favour for a different valuation of time savings and losses. One study showed that the difference in willingness to pay and willingness to accept using a revealed preference study was significant lower than using a stated preference experiment. Also the literature suggested that this effect must be measured using revealed preference analysis. For this master thesis it was not possible to exam a revealed preference study, so therefore this point is not further explored in this report.

Income dependent value of travel time: At this point most of the foreign value of travel time studies reject a income dependent value of travel time, despite the fact that they all find a relation between the monthly income and the value of travel time. Some of the reports state that the income dependency is already adopted into the different categories of travel purposes and modes. Others state that huge infrastructure projects affect all income groups and therefore an average value of travel time can be used.

For a more accurate use of income dependent value of travel time in social cost benefit analyses, the value of travel time should be dependent on the income, on the travel purpose and on the travel mode. To do so a very huge questionnaire is needed to draw significant conclusions. A disadvantage of very big questionnaires is that the reliability of the output is lower. In order to compensate for that effect a very large sample is needed. This was not achievable, therefore this point is not further explored in this report.

What could be the solution for the feasible possible improvements?

The performed literature study provided some suggestions to design a new stated preference experiment which is more suitable for small time savings. With this stated preference experiment an value of travel time per minute for time savings smaller than 5 minutes is estimated. The results of the stated preference experiment showed that the estimated value of travel time was valued almost three time lower than the value of travel time key-figure which is currently used for the calculation of the travel time benefits. In line with literature, 75 per cent of the respondents state that the time threshold of small time savings should be set between 5 and 10 minutes.

Because of the relatively small sample size, the results should be interpreted with caution. Furthermore, the respondents were on average better educated and have on average a higher monthly income, compared to the general Dutch population. Nevertheless the research indicates that there is a trend that small time savings are lower valued. Especially because in general people with higher incomes value travel time higher.

What are the effects of these solutions in a social cost benefit analyses?

In a case study three methods were used to measure the effects on the travel time benefits. The following three methods were used:

- Constant value of travel time;
- Step function;

- General Linear Discounting function.

Outcomes showed that travel time benefits are much lower if a different value of travel time key-figure for small travel time savings is used.

What is, for car drivers, the recommended method to assess the travel time savings in social cost benefit analyses?

At the beginning of this study three subjects were identified that could possibly be improved. After the literature review only one subject remained for further research. The other two subjects were rejected because it was not possible investigating these subjects within the time represented for this thesis research. So the final conclusion is mainly about the subject 'small time savings'.

The performed literature study showed suggestions to improve SP experiments, which were used to design a SP experiment which is more suitable for the valuation of small time savings. By implementing this SP experiment it became clear that there is a trend that small (< 5 min.) time savings are significant lower valued than normal time savings.

The case study demonstrated that travel time benefits will significantly decrease when a value of travel time for small time savings is implemented. These results are consistent with the opinion of Van Wee (2013), who stated that currently small time savings are over valued.

Because of these findings, there is reason to believe that small time saving benefits should be calculated otherwise in SCBA's. To confirm these results, more research on this subject is required.

7.2 REFLECTION

The research started with the first question: "What are the possible improvements in the current Dutch value of travel time determination and in the use of value of travel time in social cost benefit analyses?". To answer that question analysis of the Dutch value of travel time study of 1998 and of the Dutch value of travel time study of 2013 has been made. The Dutch value of travel time study of 2013 is used to describe the differences between the 1998 and 2013 studies. Because of the late publication of the 2013 value of travel time study there was chosen for this construction, instead of an analysis of only the 2013 value of travel time study. Despite this construction the founded possible improvements are applicable for both Dutch value of travel time studies.

In the second phase of this research the following question is central: "What does other literature tell about the feasibility of these possible improvements?". To research the feasibility of these possible improvements foreign value of travel time studies plus general literature on these subjects has been reviewed. In total six foreign value of travel time studies has been used for this review. The six foreign value of travel time studies that have been used are from the following countries: Denmark, Norway, United Kingdom, Sweden, Switzerland and the United States. There are some reasons why there is chosen for these six value of travel time studies. First the value of travel time studies of Denmark, Norway, United Kingdom, Sweden and Switzerland all use stated preference experiments to gather their data. Therefore it is easy to compare the value of travel time studies with the Dutch value of travel time study. The designs of the stated preference surveys are different for all the value of travel time studies, to ensure that new aspect and ideas may be found to get new insights for the possible improvements. The reason why there was chosen for the value of travel time study of the United States is that this study did not used an stated preference survey. This other research method again provide some new insights concerning the possible improvements.

In the third phase a research was done concerning the valuation of small time savings. To do so a stated preference experiment has been designed by using the recommendations found in the literature. The most

important recommendations in comparison to the current design of the stated preference experiment used in the Dutch value of travel time study were:

- Using respondents with short distance travels;
- Using smaller time constraints in the stated preference experiment;
- Using stated preference questions which not reflecting to a unique reference trip.

The stated preference experiment was presented to a group of 841 respondents. These respondents were recruited within the company Witteveen+Bos. A disadvantage of this sample is that it is not a perfect reflection of the Dutch society. The respondents were on average higher educated and had on average an higher monthly income. Also most of the respondents live in the east of The Netherlands. By using this sample it was not possible to state hard conclusions from the stated preference analyses. It was however possible to show a trend of the valuation of small time savings.

It can be expected that this estimated value of travel time for small time savings is higher than if a more average group was used in the stated preference experiment. Because all the value of travel time studies show that the value of travel time grows with the income, that higher educated people have a higher. However, this is only an assumption.

A different way to research the valuation of small time is an revealed preference study. This type of research does fit better for the determination of small time savings. Unfortunately it is not possible to do such a research in The Netherlands, because there is not a route where people have to pay for small time savings.

In this fourth phase the effects of the new value of travel time figures were measured during a case study. The case is an existing Dutch medium size road project, whereby the data of the traffic model was split into different categories of time saving. Due this disaggregated traffic model it became possible to implement the new value of travel time key-figures into the travel time saving benefit calculation. For the calculation of the travel time benefits three different models were used to show effects of the lower valuation of small time savings.

The outcomes of the case study shows that the travel time benefits of this specific project is much lower if a different value of travel time key-figure for small travel time savings is used. These outcomes shall vary per project dependent on the amount of small time saving. In this project the amount of time savings smaller than 5 minutes is 61% of the total time saving. Therefore the effects were significant high.

7.3 RECOMMENDATIONS

This paragraph will provide recommendation for further research and policy makers.

7.3.1 RECOMMENDATIONS FOR FURTHER RESEARCH

This report showed that there is a trend whereby people value small time savings lower than normal time savings. Because of the small sample size and characteristics of respondents it remains uncertain whether the results are representative for the Dutch society. Therefore recommendations for further research are described.

The sample used for the stated preference experiment during this research was too small and selective, making the results less reliable. With this small and selective sample is shown that there is a trend that small time savings are lower valued. To confirm this trend a stated preference experiment with a bigger and non-selective sample is needed. In addition, the trend is only demonstrated for commuting car drivers. To use different key-figures in social cost benefits analyses the value of travel time should also be determined for

other traffic purposes and methods. When further research is performed it is possible to make sensible judgments on the valuation of small time savings.

It is possible to analyse value of travel time with a Panel Latent Class models instead of the Multinomial Logit utility function, which is used in this report. The Panel Latent Class model was used in the 2013 Dutch Value of Time study. This model has the advantage that it reduces the bias which can occur in the Value of Time with the use of a Multinomial Logit model (Warffemius, 2013). In the Panel Latent Class model is assumed that there are different classes of travellers, each with their own value of travel time. The model estimates the probability that a respondent belongs to each of these classes. The final value of travel time is the average of the value of travel times of every class, weighted by the probability that a respondent belonged to each of the classes. The Panel Latent Class models are advanced Multinomial Logit utility functions, and are internationally fully accepted to calculate the value of time. Therefore they provide a good alternative for further research on valuation of small time savings.

In both models it is possible to estimate the value of travel time per level of time saving (de Jong, et al., 2012). Therefore it is possible to estimate the value of travel time for each level of time change, if the stated preference experiment design includes time saving levels of these time changes. As a result, it is possible to estimate the value of travel time per minute for each time change until 5 minutes. These value of travel time units can then be used for the calculation of the travel time benefits. This makes the use of a step function or General Linear Discounting function unnecessary and will improve the reliability of the travel time benefits. For that reason more research on this subject is recommended.

Beside better and more accurate value of time figures also the reliability of the origin/destination matrices should be improved. Otherwise a false precision will be created. In the near future the reliability of the origin/destination can possible be improved by connecting the navigation systems and telecom.

7.3.2 RECOMMENDATIONS FOR POLICY MAKERS

Considering the results of this research, currently the travel time benefits are probably overestimated. . Causing that results of social cost benefit analyses for infrastructure projects are also overrated. So it is possible that some of these infrastructure projects are not economic feasible, due to this overrating of travel time benefits.

This report recommends that the policy makers should rewrite the guidelines for social cost benefit analyses, if further research confirms the trend showed. They should adopt a method to calculate the travel time benefits for small time saving in these guidelines. Making it possible to better check the feasibility of a project. So that project which are not feasible could be rejected, making more funding available for other projects.

Before new research on small time savings is finished they should categorise time savings into the social cost benefit analyses. This will give a quick overview of time savings. In the United Kingdom this system is already introduced (Daly, Tsang, & Rohr, 2012). The social cost benefit analyses provide extra information, by categorising the travel time savings. This allows policy makers to make better decisions.

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APPENDIX I: LIST OF INTERVIEWEES

Name:	Institute:	Function:
Pim Warffemius	Kennisinstituut voor Mobiliteitbeleid (KiM).	Researcher - Project Manager in transportation economics
Carl Koopmans	SEO Economic Research	Research director
Bas Turpijn	Diens Verkeer en Scheepvaart (DVS)	Transportation Economist & Cost Engineer
Gerbert Romijn	Central Plan Bureau (CPB)	Programme Director: Sector 5 Physical environment
Piet Rietveld	Vrije Universiteit Amsterdam (VU Amsterdam)	Full Professor
Gerard de Jong	Significance	Director

APPENDIX II: SC DESIGN

Attributes:	2 levels				total levels		Factorial combination:
Time	0	-3	-5		3 named 0, 1, 2		$4^1 \cdot 3^1$
Costs	0	0,25	0,75	1,25	4 named 0, 1, 2, 3		12

Explanation levels costs:

known:	9,71 €/hour =	0,16 €/min	0,49 €/3min	0,81 €/5min					
chosen:	smallest is 50 % of 3 minutes, largest is 150 % of 5 minutes and the medium is in the middle of the two extremes all rounded on 10 cents								0,2 1,2 0,7

Possible combination:

0-0	0-1	0-2	0-3
1-0	1-1	1-2	1-3
2-0	2-1	2-2	2-3

Possible choice sets & difference vectors:

00-01	[01]	00-23	[11]	01-23	[11]	03-10	[11]	10-13	[01]	11-23	[11]	13-23	[10]
00-02	[01]	01-02	[01]	02-03	[01]	03-11	[11]	10-20	[10]	12-13	[01]	20-22	[01]
00-03	[01]	01-03	[01]	02-10	[11]	03-12	[11]	10-21	[11]	12-20	[11]	20-23	[01]
00-10	[10]	01-10	[11]	02-11	[11]	03-13	[10]	10-22	[11]	12-21	[11]	21-22	[01]
00-11	[11]	01-11	[10]	02-12	[10]	03-20	[11]	10-23	[11]	12-22	[10]	21-23	[01]
00-12	[11]	01-12	[11]	02-13	[11]	03-21	[11]	11-12	[01]	12-23	[11]	22-23	[01]
00-13	[11]	01-13	[11]	02-20	[11]	03-22	[11]	11-13	[01]	13-20	[11]		
00-20	[10]	01-20	[11]	02-21	[11]	03-23	[10]	11-20	[11]	13-21	[11]		
00-21	[11]	01-21	[10]	02-22	[10]	10-11	[01]	11-21	[10]	20-21	[01]		
00-22	[11]	01-22	[11]	02-23	[11]	10-12	[01]	11-22	[11]	13-22	[11]		

Upper bound

Omdat $l_q > 2$ en $> m$ geldt: $m(m-1)/2$. Hieruit volgt dat $2(2-1)/2=1$

[0,1]	S1=0	S2=1
[1,0]	S1=1	S2=0
[1,1]	S1=1	S2=2

Only this difference vector achieves the upper bound for both attributes

<i>v1: [0.1]</i>	<i>v2: [1,0]</i>	<i>v3: [1.1]</i>	Possible designs:			
00-01	00-10	00-11	Dominat choice sets			
00-02	00-20	00-12	Remained choice sets after removing the dominant choices			
00-03	01-11	00-13	00-11	00-23	02-13	11-22
01-02	01-21	00-21	00-12	01-12	02-23	11-23
01-03	02-12	00-22	00-13	01-13	10-21	12-23
02-03	02-22	00-23	00-21	01-22	10-22	
10-11	03-13	01-10	00-22	01-23	10-23	
10-12	03-23	01-12	Desing 1			
10-13	10-20	01-13	00-11	Desing 2		
11-12	11-21	01-20	00-12	01-23	Desing 3	
11-13	12-22	01-22	00-13	02-13	00-11	Design 4
12-13	13-23	01-23	00-21	02-23	02-13	00-12
20-21		02-10	00-22	10-21	00-13	02-23
20-22		02-11	00-23	10-22	10-21	00-21
20-23		02-13	01-12	10-23	00-22	10-22
21-22		02-20	01-13	11-22	10-23	00-23
21-23		02-21	01-22	11-23	01-12	11-22
22-23		02-23		12-23	11-23	01-13
		03-10			01-22	12-23
		03-11				
		03-12				
		03-20				
		03-21				
		03-22				
		10-21				
		10-22				
		10-23				
		11-20				
		11-22				
		11-23				
		12-20				
		12-21				
		12-23				
		13-20				
		13-21				
		13-22				

Desing 3	Design 4
00-11	01-23
02-13	00-12
00-13	02-23
10-21	00-21
00-22	10-22
10-23	00-23
01-12	11-22
11-23	01-13
01-22	12-23

Designs used in the SC experiment

APPENDIX III: QUESTIONNAIRE

INTRODUCTION

As part of my master thesis I am doing a research concerning the use of travel time valuation in SCBA's. The final goal of my research will be a recommendation of point which could improve the use of travel time valuation in SCBA's.

One of these improvement points could be a lower valuation of small time savings. From the literature study I have done follows that almost all value of time studies show that small time savings are lower valued. Despite these findings is a lower valuation for small time savings nearly used in SCBA's. Some arguments here for are that one thinks that the research design effects the results of the small time savings. So to see whether small time savings are really valued lower is an extra research needed.

This questionnaire is designed for small time savings only and for this research I need your help! It would be very helpful if you will answer the following questionnaire, this will only take 5 á 8 minutes.

PART 1: GENERAL QUESTION

Gender?	
Male	Female

Age?			
18 - 20 year	21 - 35 year	36 - 50 year	51 - 65 year

GENERAL QUESTION CONCERNING THE LIVING/WORK JOURNEY

What is your average travel time between your living area and working place?				
0 - 10 min.	11 - 20 min.	21 - 30 min.	31 - 40 min.	More than 41 min.

What is the distance between your living area and working place?			
0 - 10 km	11 - 20 km	21 - 30 km	More than 31 km

For your journey between living area and working place which travel mode do you normally use?				
Walk	Bike	Bus/Tram	Train	Car

If you travel by car for your living area/working place trip, do you carry passengers? If yes, how many?				
No passengers	1 Passenger	2 Passengers	3 Passengers	4 Passengers

If you travel by car for your living area/working place trip, do you on average experience any traffic jams? If yes what is your extra travel time due to these traffic jams?					
No traffic jams	0 - 5 min.	5 - 10 min.	11 - 15 min.	16 - 20 min.	More than 21 min.

Is your living place/working place travel costs compensated?			
No	Yes, complete compensated	Yes, partly compensated	Yes, shared with passengers

QUESTION CONCERNING YOUR ACTIVITIES DURING YOUR LIVING AREA/ WORKING PLACE JOURNEY

Do you use your travel time for other useful activities beside travelling itself? If yes, for which activity do
--

you use that travel time?				
No	Work	Eat	Relax	Other

QUESTION CONCERNING TRAVEL TIME SAVINGS

Which amount of time saving would you describe as useful time saving?					
Every minute	3 minutes	5 minutes	10 minutes	20 minutes	More than 20 min.

On which activity would you spend that amount of time saving?	
Work	Relax

PART 2: CHOICE SETS

Short explanation and example question:

As a variation of the saying “time is money” is generally that people are willing to pay for faster transport and vice versa that they are willing to accept for slower transport.

In the following question, each two different situations shall be presented. The situations are based on your average living area / working place journey, so keep that average trip in mind. In each situation you must imagine that you pay the travel costs by yourself, also if you normally get your travel costs compensated.

An example question:

<p>O Option A</p> <p>Travel time is the same as the current situation</p> <p>Travel costs are the same as the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter as the current situation</p> <p>Travel costs €1,20 more expensive as the current situation</p>
---	--

- Situation A is exactly the same as your normal living area / working place journey;
- In situation B are the travel costs €1,20 more expensive as your average travel costs, but are you 3 minutes earlier on your destination.
- If you prefer situation A more than situation B, than you must select option A. And vice versa if you prefer situation B more than situation A, you must select option B.

Question:

The goal of the following 10 questions is, that you each time choose your most preferred situation. Take in mind that you make your living area / working place journey regularly and that amount of presented time savings and travel costs will count for each time that you make your living area / working place journey!

<p>O Option A</p> <p>Travel time is 5 minutes short than the current situation</p> <p>Travel costs are €0,20 more expensive than the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter than the current situation</p> <p>Travel costs are the same as the current situation</p>
--	--

<p>O Option A</p> <p>Travel time is the same as the current situation</p> <p>Travel costs are €0,20 more expensive than the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter as the current situation</p> <p>Travel costs are €0,70 more expensive as the current situation</p>
---	--

<p>O Option A</p> <p>Travel time is 3 minutes shorter than the current situation</p> <p>Travel costs are €1,20 more expensive than the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter as the current situation</p> <p>Travel costs €0,20 more expensive as the current situation</p>
--	--

<p>O Option A</p> <p>Travel time is the same as the current situation</p> <p>Travel costs are the same as the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter as the current situation</p> <p>Travel costs €1,20 more expensive as the current situation</p>
---	--

<p>O Option A</p> <p>Travel time is 5 minutes shorter than the current situation</p> <p>Travel costs are €0,70 more expensive than the current situation</p>	<p>O Option B</p> <p>Travel time is the same as the current situation</p> <p>Travel costs €0,20 more expensive than the current situation</p>
--	---

<p>O Option A</p> <p>Travel time is 3 minutes shorter than the current situation</p> <p>Travel costs are the same as the current situation</p>	<p>O Option B</p> <p>Travel time is 5 minutes shorter as the current situation</p> <p>Travel costs €1,20 more expensive than the current situation</p>
--	--

<p>O Option A</p> <p>Travel time is 5 minutes higher than the current situation</p> <p>Travel costs are €1,20 more expensive than the current situation</p>	<p>O Option B</p> <p>Travel time is the same as the current situation</p> <p>Travel costs is the same as the current situation</p>
---	--

<p>O Option A</p> <p>Travel time is 3 minutes shorter than the current situation</p> <p>Travel costs are €0,70 higher than the current situation</p>	<p>O Option B</p> <p>Travel time is 5 minutes shorter than the current situation</p> <p>Travel costs €0,20 more expensive than the current situation</p>
--	--

<p>O Option A</p> <p>Travel time is the same as the current situation</p> <p>Travel costs are €0,70 higher than the current situation</p>	<p>O Option B</p> <p>Travel time is 3 minutes shorter as the current situation</p> <p>Travel costs €1,20 more expensive as the current situation</p>
---	--

END OF QUESTIONNAIRE

You have finished the questionnaire. Thank you for your corporation!

APPENDIX IV: RESULTS QUESTIONNAIRE

Sex:	Set 1	Set 2	Total	%
Male:	9	29	38	64%
Female:	6	14	20	34%
No answer:	1	0	1	2%

Age:	Set 1	Set 2	Total	%
18 - 20 year	0	0	0	0%
21 - 35 year	8	22	30	51%
36 - 50 year	3	15	18	31%
50 - 65 year	5	6	11	19%

Travel time:	Set 1	Set 2	Total	%
0 - 10 min.	0	0	0	0%
11 - 20 min.	10	15	25	42%
21 - 30 min.	2	17	19	32%
31 - 40 min.	3	6	9	15%
more than 40 min.	1	5	6	10%

Travel distance:	Set 1	Set 2	Total	%
0 - 10 km	6	5	11	19%
11 - 20 km	7	26	33	56%
21 - 30 km	2	7	9	15%
more - 30 km	1	5	6	10%

Travel cost:	Set 1	Set 2	Total	%
Paid by respondent	8	5	13	22%
(Partly) compensated	8	38	46	78%

Travel time use:	Set 1	Set 2	Total	%
Only travelling	10	21	31	53%
Work/eat/talk/etc.	6	22	28	47%

Useful time saving:	Set 1	Set 2	Total	%
every minute	1	9	10	17%
3 minutes	3	0	3	5%
5 minutes	9	11	20	34%
10 minutes	3	21	24	41%
20 minutes	0	1	1	2%
More than 20 min.	0	1	1	2%

Traffic jams:	Set 1	Set 2	Total	%
Yes	4	21	25	42%
No	12	22	34	58%

Passengers:	Set 1	Set 2	Total	%
Yes	3	6	9	15%
No	13	37	50	85%

APPENDIX V: INPUT MAIN SP EXPERIMENT

***.dat file:**

NR	Sit.	Choice	Const	Cost1	Time1	Cost2	Time2	AV1	AV2
1	1	1	2	1 .20	-5.00	.00	-3.00	1	1
1	2	1	1	1 .20	.00	.70	-3.00	1	1
1	3	2	1	1 .20	-3.00	.00	.00	1	1
1	4	2	1	1.20	-5.00	.20	-3.00	1	1
1	5	1	1	.00	.00	1.20	-3.00	1	1
1	6	2	1	.70	-5.00	.20	.00	1	1
1	7	1	1	.00	-3.00	1.20	-5.00	1	1
1	8	2	1	1.20	-5.00	.00	.00	1	1
1	9	1	1	.70	.00	1.20	-3.00	1	1
2	1	2	1	.20	-5.00	.00	-3.00	1	1
2	2	2	1	.20	.00	.70	-3.00	1	1
2	3	2	1	.20	-3.00	.00	.00	1	1
2	4	2	1	1.20	-5.00	.20	-3.00	1	1
2	5	1	1	.00	.00	1.20	-3.00	1	1
2	6	1	1	.70	-5.00	.20	.00	1	1
2	7	1	1	.00	-3.00	1.20	-5.00	1	1
2	8	2	1	1.20	-5.00	.00	.00	1	1
2	9	1	1	.70	.00	1.20	-3.00	1	1
3	1	2	1	.20	-5.00	.00	-3.00	1	1
3	2	1	1	.20	.00	.70	-3.00	1	1
...

***.mod file**

// File model.mod

[ModelDescription]
"generieke effecten"

[Choice]
Choice

[Beta]
// Name Value LowerBound Upperbound status (0=variable, 1=fixed)
asc1 0 -10000 10000 0
asc2 0 -10000 10000 0
beta1 0 -10000 10000 0
beta2 0 -10000 10000 0

[Utilities]
// Id Name Avail linear-parameter expression (beta1*x1 + beta2*x2 + ...)
1 Option1 AV1 asc1 * Const + beta1 * Cost1 + beta2 * Time1
2 Option2 AV2 asc2 * Const + beta1 * Cost2 + beta2 * Time2

[Model]
\$MNL

APPENDIX VI: EXPLANATION OF THE VOTT ESTIMATION PROCESS

- From the data resulting of the SP experiment is know which choice option is chosen (2) or is not chosen (1);
- The choices are made because the respondents chooses the choice option with the highest utility. The utilities of the choice options are determined by utility function:

$$V_{i\alpha} = \text{constant} + \beta_{\text{costs}} \text{Costs} + \beta_{\text{time}} \text{Time}$$

- The multinomial logit model describes how the utilities determine the chance that a certain option is chosen by:

$$p = \frac{e^{V_{i\alpha}}}{\sum e^{V_i}}$$

- The unknown figures in this formula are the parameters β_{costs} and β_{time} ;
- The parameters are searched using a trial and error method. The parameters which provide the maximum value for the log likelihood are chosen.

APPENDIX VII: RESULTS SP EXPERIMENT

MAIN RESULTS CAR:

Michel Bierlaire, EPFL

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07/01/13 10:19:44

generieke effecten

Model: Multinomial Logit

Number of estimated parameters: 4

Number of observations: 531

Number of individuals: 531

Null log-likelihood: -368.061

Cte log-likelihood: -366.318

Init log-likelihood: -368.061

Final log-likelihood: -204.762

Likelihood ratio test: 326.599

Rho-square: 0.444

Adjusted rho-square: 0.433

Final gradient norm: +2.789e-005

Diagnostic: Convergence reached...

Iterations: 6

Run time: 00:00

Variance-covariance: from analytical hessian

Sample file: test totaal.dat

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.128	3.96e+006	-0.00	1.00	*	1.80e+308	-0.00	1.00	*
asc2	0.128	3.96e+006	0.00	1.00	*	1.80e+308	0.00	1.00	*
beta1	-4.03	0.423	-9.55	0.00		0.430	-9.37	0.00	
beta2	-0.250	0.0611	-4.08	0.00		0.0590	-4.23	0.00	

Utility functions

1	Option1	AV1	asc1 * Const + beta1 * Cost1 + beta2 * Time1
2	Option2	AV2	asc2 * Const + beta1 * Cost2 + beta2 * Time2

Correlation of coefficients

Coefficient1	Coefficient2	Covariance	Correlation	t-test	p-value		Rob. cov.	Rob. corr.	Rob. t-test	p-value	
asc1	asc2	1.57e+013	1.00	0.00	1.00	*	-0.00150	-0.837	0.00	1.00	*
asc1	beta2	-0.00248	-1.02e-008	0.00	1.00	*	-0.00186	0.00	1.49	0.14	*
asc2	beta2	-0.00507	-2.09e-008	0.00	1.00	*	-0.00444	0.00	4.68	0.00	
asc1	beta1	-0.00799	-4.77e-009	0.00	1.00	*	0.00111	0.00	9.15	0.00	
asc2	beta1	-0.0289	-1.73e-008	0.00	1.00	*	-0.0235	0.00	8.75	0.00	
asc1	asc2	1.57e+013	1.00	-1.40	0.16	*	-0.0197	-11.0	-1.41	0.16	*
beta1	beta2	0.0218	0.843	-10.16	0.00		0.0205	0.809	-9.85	0.00	

Smallest singular value of the hessian: 3.18152e-014

Unidentifiable model

The log-likelihood is (almost) flat along the following combinations of parameters

Sing. value = 3.18152e-014

0.707089 * asc1

0.707089 * asc2

0.00353547 * Param[4]

0.00353542 * Param[5]

-0.00353542 * Param[8]

-0.00353547 * Param[9]

OTHER RESULTS CAR:

Utility parameters: respondents with declaration

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.128	1.80e+308	-0.00	1.00	*	0.0987	-1.29	0.20	*
asc2	0.128	1.80e+308	0.00	1.00	*	0.0843	1.51	0.13	*
beta1	-3.95	0.435	-9.08	0.00		0.437	-9.04	0.00	
beta2	-0.297	0.0655	-4.53	0.00		0.0633	-4.69	0.00	

Utility parameters: respondents without declaration

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	0.0178	4.90e+007	0.00	1.00	*	1.80e+308	0.00	1.00	*
asc2	-0.0178	4.90e+007	-0.00	1.00	*	1.80e+308	-0.00	1.00	*
beta1	-5.01	1.87	-2.68	0.01		1.72	-2.92	0.00	
beta2	-0.0254	0.245	-0.10	0.92	*	0.254	-0.10	0.92	*

Utility parameters: respondents who don't tasks

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.186	1.80e+308	-0.00	1.00	*	1.80e+308	-0.00	1.00	*
asc2	0.186	1.80e+308	0.00	1.00	*	1.80e+308	0.00	1.00	*
beta1	-4.01	0.675	-5.94	0.00		0.738	-5.43	0.00	
beta2	-0.128	0.0936	-1.36	0.17	*	0.0962	-1.33	0.18	*

Utility parameters: respondents who do tasks

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.0695	1.80e+308	-0.00	1.00	*	1.10e+006	-0.00	1.00	*
asc2	0.0695	1.80e+308	0.00	1.00	*	1.10e+006	0.00	1.00	*
beta1	-4.20	0.561	-7.49	0.00		0.530	-7.92	0.00	
beta2	-0.385	0.0873	-4.41	0.00		0.0815	-4.72	0.00	

Utility parameters: respondents with short travel time

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.118	1.80e+308	-0.00	1.00	*	2.25e+006	-0.00	1.00	*
asc2	0.118	1.80e+308	0.00	1.00	*	2.25e+006	0.00	1.00	*
beta1	-3.87	0.674	-5.74	0.00		0.672	-5.77	0.00	
beta2	-0.205	0.0990	-2.08	0.04		0.0962	-2.13	0.03	

Utility parameters: respondents with long travel time

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.131	1.80e+308	-0.00	1.00	*	0.137	-0.96	0.34	*
asc2	0.131	1.80e+308	0.00	1.00	*	1.80e+308	0.00	1.00	*
beta1	-4.13	0.540	-7.64	0.00		0.556	-7.42	0.00	
beta2	-0.277	0.0778	-3.56	0.00		0.0748	-3.70	0.00	

MAIN RESULTS BICYCLE:

Michel Bierlaire, EPFL

This file has automatically been generated.

07/01/13 10:48:46

generieke effecten

Model: Multinomial Logit

Number of estimated parameters: 4

Number of observations: 575

Number of individuals: 575

Null log-likelihood: -398.560

Cte log-likelihood: -398.246

Init log-likelihood: -398.560

Final log-likelihood: -239.001

Likelihood ratio test: 319.117

Rho-square: 0.400
Adjusted rho-square: 0.390
Final gradient norm: +6.207e-008
Diagnostic: Convergence reached...
Iterations: 6
Run time: 00:00
Variance-covariance: from analytical hessian
Sample file: test total.dat

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
asc1	-0.169	3.83e+006	-0.00	1.00	*	2.47e+006	-0.00	1.00	*
asc2	0.169	3.83e+006	0.00	1.00	*	2.47e+006	0.00	1.00	*
beta1	-2.85	0.382	-7.47	0.00		0.385	-7.41	0.00	
beta2	-0.0684	0.0659	-1.04	0.30	*	0.0659	-1.04	0.30	*

Utility functions

1	Option1	AV1	asc1 * Const + beta1 * Cost1 + beta2 * Time1
2	Option2	AV2	asc2 * Const + beta1 * Cost2 + beta2 * Time2

Correlation of coefficients

Coefficient 1	Coefficient 2	Covariance	Correlation	t-test	P-value		Rob. cov.	Rob. corr.	Rob. t-test	P-value	
asc1	beta2	0.0218	8.65e-008	-0.00	1.00	*	0.0288	1.77e-007	-0.00	1.00	*
asc2	beta2	0.0185	7.34e-008	0.00	1.00	*	0.0256	1.57e-007	0.00	1.00	*
asc1	beta1	0.0928	6.35e-008	0.00	1.00	*	0.118	1.25e-007	0.00	1.00	*
asc2	beta1	0.0726	4.97e-008	0.00	1.00	*	0.0959	1.01e-007	0.00	1.00	*
asc1	asc2	1.46e+013	1.00	-2.41	0.02		6.10e+012	1.00	-0.00	1.00	*
beta1	beta2	0.0215	0.855	-8.51	0.00		0.0211	0.831	-8.38	0.00	

Smallest singular value of the hessian: 3.41317e-014

Unidentifiable model

The log-likelihood is (almost) flat along the following combinations of parameters

Sing. value = 3.41317e-014

0.707089 * asc1

0.707089 * asc2

0.00353548 * Param[4]

0.00353542 * Param[5]

-0.00353542 * Param[8]

-0.00353548 * Param[9]

APPENDIX VIII: DATA CASE

Data travel time savings case

Purpose:	Time saving categories:	hours time saved:	perc.	cum.
All	0-1 minute	1258	18%	18%
	1-2 minute	1158	17%	35%
	2-5 minute	1875	27%	62%
	5-10 minute	1342	20%	82%
	10-20 minute	1026	15%	97%
	>20 minute	207	3%	100%
	Total	6866		
Commute	0-1 minute	680	17%	17%
	1-2 minute	666	16%	33%
	2-5 minute	1157	28%	61%
	5-10 minute	833	20%	82%
	10-20 minute	612	15%	97%
	>20 minute	128	3%	100%
	Total	4076		
Business	0-1 minute	247	15%	15%
	1-2 minute	258	16%	32%
	2-5 minute	402	25%	57%
	5-10 minute	343	21%	78%
	10-20 minute	292	18%	97%
	>20 minute	54	3%	100%
	Total	1596		
Other	0-1 minute	331	28%	28%
	1-2 minute	234	20%	47%
	2-5 minute	316	26%	74%
	5-10 minute	166	14%	88%
	10-20 minute	122	10%	98%
	>20 minute	25	2%	100%
	Total	1194		

