The Monetary Value of a Pleasant and Productive Train Trip

Developing an experimental method for estimating the monetary value of activities performed during travel

Kingsley Adjenughwure 8/13/17 Master Thesis (TU Delft)

"When time flies it is because you enjoy that time. When time looks very slow it is because you are not enjoying; thirteen years was like a finger click".

Jose Mourinho (Former Chelsea, Inter Milan, Real Madrid and current Manchester United boss). 25/07/2017 BBC interview.

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Preface

The past 6months have been spent largely on working on this challenging but exciting project. When I first discussed this project with my potential supervisors a year ago, I wasn't sure if it was even possible to actually estimate the monetary value of being able to read or listen to music during a train trip. This thesis proves that it is indeed possible!

Throughout the duration of the project, I have had a lot of support from various people. Due to the nature of the project, I was privileged to have a very complete team (in every sense). First, I want to thank my company supervisor at Netherlands Railways(NS), Menno de Bruyn, for his help in explaining the project to me in very simple terms, for his valuable input, advice and encouragement throughout the course of the thesis. It meant a lot to me that he was confident he got the right person for the project even though he barely knew me. This made it easier for me to work without any fear or inferiority complex. I also would like to thank Mark, Mats, Niek, Mignon, Nina and other colleagues at NS for agreeing to help as test respondents. This really helped to make some vital changes and improve the understanding of the survey.

I also would like to thank Eric Molin for his immense contribution to the final survey design. His vast experience on design of surveys proved to be very valuable. I Initially underestimated the importance (and difficulty!) of designing a good survey. Luckily, the pilot survey helped me to revaluate my stance and take the design of the main survey more seriously. I also thank Oded Cats for his contribution to the overall quality of the thesis especially on the practical implications of results on a tactical and operational level. He made me realise that apart from policy implications, result could also have effect on schedules, route choice, departure time etc of travellers.

I want to thank Caspar Chorus for his help in securing the internship at NS and also for making sure that I focused on the most important aspects of the thesis. His constructive criticism of my work helped to immensely improve the quality of methods, models, and overall content of the thesis. Having taken his classes and worked with him during my honours program, I didn't expect less. I would say it wasn't easy but it was definitely worth it.

I also want to thank Pim Warffemius from KiM for his valuable input throughout the stages of the project. We had a lot of lively discussions both physically and via email especially on how my research relates to the value of comfort. His interest on the project alone, made me realize that this research could have an impact even on future VOTTS calculation of the Netherlands.

I would also like to thank Stavros and Femke from SKIM who helped programmed the survey. Given the unique nature of the survey, the programming was not an easy task. I thank them for being patient with me and reasoning with me when needed.

I also would like to thank the Transport Institute of TU Delft for granting me a full scholarship to study for two years in Delft. Without this scholarship, I wouldn't have been able to afford to study in Delft. So I am grateful for the opportunity.

I want to thank my family and my Mount Zion Delft parish members for their moral and spiritual support throughout my studies in Delft. Finally, I thank God for His grace and favour. To Him be all the glory and praise.

Abstract

The value of travel time saving(VOTTS) is very important in cost benefit analysis(CBA) as it is used to calculate the monetary gain in case of an improvement in transport that leads to reduction in travel time. Although it is easy to directly calculate monetary gains due to a speed improvement, monetary gains due to transport service improvement like comfort or ability to perform useful activities during a trip are far more difficult to include in CBA. This is because the total travel time stays the same before and after such service improvement since there is no visible reduction in total travel time. This is of course not true because travelers who travel comfortably and are able to engage in productive and pleasant activities during their trip can derive some benefits from the trip. These benefits can have an impact on the traveler's VOTTS e.g. a reduction in the VOTTS of the traveler.

In order to measure this impact and calculate the monetary value of activities, a new methodology is proposed. The intuition behind the method is that the same traveler might have two different VOTTS. One VOTTS when he/she is able to make productive or pleasant use of the travel time by engaging in a preferred activity and another VOTTS when he/she cannot engage in the preferred activity during the journey. If the VOTTS without the activity is higher than the VOTTS with the activity, then the difference between these two VOTTS can be conceptualized as the monetary value of the activity.

The proposed methodology was translated into a hypothetical stated choice experiment with in-vehicle time and cost attributes. Respondents were recruited from train travellers on Netherlands Railways(NS) panel. The VOTTS of respondents with and without the ability to perform their preferred activity was then calculated. The results show that the ability to perform certain preferred activities like reading, working and listening to music during train trips, reduces the VOTTS especially for commuters by about 5euros/hour. For leisure travellers, reading was found to reduce the VOTTS by about 3euros/hr. The research concludes with a discussion on the general implication of results for transport project evaluations and investments. Based on this, some recommendations are made for NS and also for the Netherlands institute for transport policy analysis(KiM) regarding future VOTTS calculations that will be used in transport project evaluations.

Executive Summary

Traditionally travel time is viewed as wasted and should be reduced. However, research has revealed that people are using travel time to engage in activities such as reading, working, listening to music etc (Lyons et al 2007; Watts and Urry 2008; Gustafson 2012; Gripsrud and Hjorthol; 2012 Lyons et al 2013; Mokhtarian et al 2015). This means that travel could have some benefits which until now are currently being ignored or not correctly accounted for especially on non-business trips.

The ability of a traveller to make a journey pleasant or productive (by engaging in selected activities) is an added bonus for the traveller. However, for policy makers who use value of travel time savings(VOTTS) as an input to cost benefit analysis (CBA) of transport projects, this is a new dilemma. The debate is centred on whether these activities have an impact on the VOTTS. If they do have a significant impact, then the current VOTTS used for CBA appraisals are either underestimated or over-estimated depending on whether the impact is negative or positive on VOTTS. For example, it is easy to calculate the monetary gains from an investment that physically reduces travel time. However, it is possible that travel time is perceived less negatively when a traveller is engaged in an activity. The monetary gain from this "reduction" in travel time due to activities are not currently valued as it is done for speed. Although current research on the impact of performing activity during travel (travel-based multi-tasking) on VOTTS and on travel experience in general has steadily increased over the years, there is no consensus on how to correctly explain, capture the characteristics and calculate the impact of this travel behaviour on VOTTS.

The main research question for this thesis was thus framed as follows:

What effects does the ability to perform activities during travel have on a travelers' VOTTS and how can these effects be modelled and quantified ?

To answer the research question, a new methodology for calculating the monetary value of activities was proposed. The intuition behind the method is that the same traveler might have two different VOTTS. One VOTTS when he/she is able to make productive or pleasant use of the travel time by engaging in a preferred activity and another VOTTS when he/she cannot engage in the preferred activity during the journey. If the VOTTS without the activity is higher than the VOTTS with the activity, then the difference between these two VOTTS can be conceptualized as the monetary value of the activity.

The methodology was translated into a hypothetical stated choice experiment with in-vehicle time and cost attributes. Respondents were recruited from train travellers on Netherlands Railways(NS) panel. In this experiment train travellers were asked to imagine they forgot what they need to perform certain ***preferred activities***, hence they are not able to perform the intended activity throughout the journey (but can still perform other activities). Also, ***the same travellers*** are asked to reimagine that they have all they need to perform the activity and hence can perform the activity for the whole journey. The VOTTS of these

travellers for the two different contexts were then compared. The monetary value of these preferred activities was then calculated as the difference between these two VOTTS.

It is important to note that the context was changed and not the respondents. This is a very crucial step in the experimental set-up. So instead of comparing VOTTS of the different people across different activities (as done in other research, see Ettema and Verschuren 2007), ***this research compares the VOTTS of the same people with same preferred activities but vary the context with and without the activity.*** This enabled the direct calculation of the monetary value of activities.

For this research the activities reading, working and listening to music were chosen based on their popularity, ease of explanation of experiment, previous literature and the characteristics of the activity (i.e. whether productive or pleasant). The trip purposes of focus are on commute and leisure trips which make up about 75% of all trips made by NS trains. The binary logit model results for all three activities are shown below:

Table summary-0-1: VOTTS of commuters

Commute	Reading	Working	Music
VOTTS with activity(€/hr)	11.22	12.72	10.08
Value of preferred activity(€/hr)	4.82	5.31	4.67
VOTTS Without preferred activity(€/hr)	16.04	18.03	14.75

Table summary 0-2: VOTTS of Leisure trips

Leisure	Reading	Working	Music
VOTTS with activity(€/hr)	4.11	6.54	5.95
Value of preferred activity(€/hr)	3.02	1.17	0.33
VOTTS Without preferred activity(€/hr)	7.13	7.71	6.27

Value of activities

The value of activities ranges from 4.67 to 5.31 euros/hour for commute trips. There seem to be no significant difference in the value of activities between commuters who read, work or listen to music. It was expected that the value of working is substantially more than

that of reading and listening to music since work is usually a paid activity. However, this was not the case. The reason could be that everyone values their favourite activity quite well.

For leisure trips, only the value of reading was significant. Value of working or listening to music during a leisure trip is essentially zero. It is possible that the activity in a leisure trip is not so much a routine compared to the activity performed during commuting. This means that the traveller can easily switch to other activities in case they are not able to perform the preferred activity.

VOTTS with activity

The VOTTS for commute who read, listen to music or work ranges from 10.08 euros/hour to 12.72 euros/hr. This is close to the current official VOTTS for commuter train trips in the Netherlands which is 11.50 euros/hour in 2010 euros (Significance,2013) or 12.76 euros/hr (equivalent 2017 euros) using an average annual inflation rate of 1.5%(inflation.eu). Also, a recent VOTTS time study by (Schakenbos et al,2016) using the panel of NS found an average VOTTS for commute and business trips of 13.21 euros/hour. This is an indication that travellers take into account the ability to perform activities in their VOTTS since this VOTTS with activity is close the current VOTTS.

For leisure trips, the VOTTS for those who read, listen to music or work range from 4.11 to 6.54 euros/hr. This is also close to the recent value obtained by (Schakenbos et al,2016) using the NS panel. For social, recreational and other trips they found VOTTS between 4.31 and 7.86 euros/hour depending on income level. The official VOTTS of the Netherlands for leisure and other trips by train is 7.00 euros/hour(Significance,2013) or 7.75 euros/hr in 2017 euros. This is also another validation of results.

Answer to research question and main conclusion from results

What effects does the ability to perform activities during travel have on a travellers' VOTTS and how can these effects be modelled and quantified

The ability to perform certain preferred activities like reading, working and listening to music during travel reduces the VOTTS especially for commuters by about 5euros/hour. For leisure traveller only reading was found to reduce the VOTTS by about 3euros/hr.

To model and quantify these effects, the specially designed SP experiment proposed in this thesis can be used. Based on the results found in this thesis, it is possible to make corrections and modifications to the current VOTTS to include activities performed during travel.

The current official VOTTS of commuters and leisure travellers in the Netherlands are close to the VOTTS with activity found in this study. This indicates that travellers could already take the ability to perform certain activities into account in their current VOTTS. So, without the ability to perform certain activities like reading, working and listening to music,

the real value of time of commuters could potentially be about 5euros/hour higher than the current value.

Potential application of results

The value of activities can be used to calculate the positive benefits of travel especially for public transport modes which enables people to engage in various activities while travelling. This could lead to potentially more investment in public transport (e.g. train) compared to other modes like car. Investment that improve the ability of travellers to engage in productive/pleasant activities during travel can be favourably compared with those investments that are meant to improve speed.

Practical recommendations

Recommendations for NS

There is ample evidence from this research that passengers are enjoying their trip more when they able to perform their preferred activities. This mean that NS should pay more attention to activities and especially the train environment. Most activities require that the passenger is able to seat and that the environment is quiet. Therefore, a noisy and crowded train will limit the ability of passengers to engage in activities. If people can make better use of their time while onboard NS trains, then this gives a competitive advantage to NS. It could potentially attract more people to use the train and also increase customer satisfaction.

On a tactical and operational level, activity patterns per route should be studied. This will make it easier to know which routes should be targeted for comfort and crowding improvement and also improvement in on board facilities for activities. For instance, frequency and departure times can be adjusted on such routes or different types of trains can be used depending on capacity, and onboard facilities to match passengers' needs. Adding more trains on a busy route can make more seat available for people to perform their activities which in turn adds more benefits.

On a strategic level, investment can be made to enable people perform their activities more effectively on the train. For instance, by providing special sections on the train for activities. These special sections can either be commercialised using passengers' willingness to pay or provided for free using the monetary value of the activity. For example, passengers can book for these sections just like booking for a first-class seat or buy tickets which allows them use these sections.

Recommendations for KiM

The most recent VOTTS study for the Netherlands revealed that VOTTS were lower than expected even after correcting for increase in income. The lower than expected values were partly attributed to the ability of travellers to make productive use of their travel time (Significance,2013, Warffemius et al 2016). The results of this thesis indicate that activities do play a role in VOTTS and it could partly explain why the VOTTS is reducing. If

opportunities for engaging in activities continue to improve, then this trend is expected to continue in the near future. It therefore recommended to incorporate the ability to perform various activities during travel in national VOTTS calculations. One way to do this, is to distinguish between the value of productive and pleasant travel time and the value of an unproductive and unpleasant travel time. This will enable the calculation of value of productive/pleasant activities that are currently been combined with travel. Furthermore, crowding and comfort should be studied in relation to activities. It is possible that some of the disutility associated with crowding and comfort are also related to the passengers' inability to perform a productive or pleasant activity during the journey.

Limitation of research

The first limitation of the research is that stated preference was used instead of revealed preference. The time and cost values are hypothetical. For example, people were not assigned SP according to their actual trip duration. They were asked to imagine that they are making a trip of that trip length. So, the real values of activities might differ from the ones calculated here. Also, the survey asked people to imagine they forgot equipment required for certain activities. Although this scenario is possible in real life, it is not frequent so most people might not have experienced it before and would not know what to do in that case. This can lead to over valuing or undervaluing the activity.

Also, some equipment can be used for various activities so, someone who normally reads a book and forgot it, can still read via a phone for instance. Respondents were also asked to consider only one trip and activity combination only when making their choices. However, it possible that they considered their inability to perform other activities also. Again, this can lead to a different value of the activity since people can still perform the activity or unable to perform other activities.

Another limitation of the research is that the survey design used does not allow for some activities to be valued. Activities that do not require equipment were excluded to avoid introducing bias related to the train environment. So, this research cannot be replicated for such activities eg. sleeping, relaxing. The values of these activities need to be calculated to get an overall picture of how all activities affect VOTTS.

Recommendations for future research

1. Research into the value of activities is relatively new so there is a lot to do in the future. More research is needed to verify results of this thesis. For example, a repeat study of this research should be done on a larger scale to verify results.

2. After this, the most relevant direction will be to revaluate current VOTTS. SP surveys should then include ability to perform activities as either context or attributes or even the number of minutes you are able to perform activities. This can be combined with crowding and other comfort attributes to get more realistic estimate of VOTTS. The VOTTS for a productive and pleasant journey should be

distinguished from the VOTTS of an unproductive/unpleasant trip to enable value of activities to be calculated.

3. A survey to calculate value of activities like sleeping, relaxing, looking outside etc is needed. For instance, a time perception experiment similar to the experiment performed for waiting time (Van Hagen,2011) can be done. So, people could be asked how much more or less the perceive their travel time while engaging in such activities. This can then be translated to monetary values.

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CHAPTER 1: INTRODUCTION

1.1. Motivation – Importance – Context

Travel has always been viewed as a means to an end i.e. a means to get to an activity location where the traveller can derive utility from undertaking that activity e.g. work, business meeting, shopping etc. The assumption is that travel is a derived demand and therefore a disutility. This assumption has been used for decades in the estimation of value of travel time savings on business, commute and other trip purposes. However, research on travel behaviour has consistently revealed that people do not only travel but make use of this opportunity to engage in activities during the trip (Lyons et al 2007; Watts and Urry 2008; Gustafson 2012; Gripsrud and Hjorthol; 2012 Lyons et al 2013; Mokhtarian et al 2015). This behaviour is even more pronounced now with the emergence of portable ICT devices like laptops, smart phones, notepads etc. Equipped with these devices, travellers especially those travelling by rail, can now work, listen to music, read, talk on the phone, and engage in a plethora of activities thus making the trip productive or pleasant. Also, with the expected emergence of automated vehicles, travellers on this type of vehicle can make productive use of their time. This means that studies on the ability to perform various activities while travelling is very relevant now and also in the future.

The ability of a traveller to make a journey pleasant or productive (by engaging in selected activities) is an added bonus for the traveller. However, for policy makers who use value of time(VOTTS) as an input to cost benefit analysis (CBA) of transport projects, this is a new dilemma. The debate is centred on whether these activities have an impact on VOTTS. If they do have a significant impact, then the current VOTTS used for CBA appraisals are either underestimated or over-estimated depending on whether the impact is negative or positive on VOTTS. Although current research on the impact of performing activity during travel (travel-based multi-tasking) on VOTTS and on travel experience in general has steadily increased over the years, there is no consensus on how to correctly explain, capture the characteristics and calculate the impact of this travel behaviour on VOTTS. The most practical method so far is the Hensher equation(Hensher,1977) which is used as productivity forgone correction for business travel. The equation is derived from time allocation and group utility maximization theory of employer and employee and uses wage rate to measure productivity(Batley,2015).

The limitation of this method that it is only valid if the trip purpose is business and the activity performed is work related. To the best of our knowledge, there is no similar practical method for activities performed during non-business trips. This means that the impact activities have on the VOTTS of non-business travellers is currently ignored. The argument for this omission is that since VOTTS of non-business trips is estimated from stated preference survey, the travellers already take this into account when making their choice (Hensher and Wang,2016). There are at least two fundamental problems with this assumption. The first and obvious one is that it has not been empirically proven. At least from a review of literature, we do not know of any survey or method that specifically proves

this. The second problem is that if the assumption is true then it doesn't make so much sense to omit the impact of activities since they play a role in the determination of VOTTS. The reasoning is, if policy makers don't care whether the impact of activities on VOTTS is a positive or negative one, then they cannot tell whether a decision to encourage or discourage activities during travel is good or bad. Given the two reasons above, this research has the following fundamental goals:

1. To develop a method to calculate the monetary value of various activities that are frequently combined with travel.
2. Use the developed method to confirm or reject (through experiment) the assumption that activities performed during a non-business trip are already taken into account in reported VOTTS from SP surveys.
3. Use the methodology to determine whether various activities have a positive or negative impact on VOTTS.
4. Provide a way to quantify positive benefits of travel (i.e. being able to perform activities) in societal CBA of transport projects. This will enable policy makers and transport operators to compare projects that are specifically meant to improve the ability to perform activities during travel with other projects like those meant to reduce travel time.

1.2. Research Objectives, Scope, Contribution

The main research question for this thesis is thus framed as follows:

What effects does the ability to perform activities during travel have on a travelers' VOTTS and how can these effects be modelled and quantified

Sub-questions

1) What activities are being combined with travel?

2) Which comfort elements and equipment are required for these activities?

3) Do travelers value time differently when they are able to perform activities during travel?

1.2.1. Goals of NS and KiM(Clients)

Dutch railways(NS) prides itself in its ability to provide safe, efficient and quality transport service to its customers. In addition to these main goals, NS is committed to making significant contribution to the betterment of the society as a whole. Therefore, if travelling by train has an added value to the society, then this will be considered a plus for NS as a company. There are different ways NS adds value to the society e.g. people being able to work and live in different locations because trains are available for them to travel, environmental benefits gained from less people travelling by cars etc. These benefits can be

monetized and used as an indication of how much value NS adds to the society. However, there are other less obvious aspects of travel with NS which also adds value to the society. One of such aspects is the ability for people to make productive and pleasant use of their travel time. Therefore, the goal of NS for this research is to know the value of activities which travelers engage in during their travel by train.

KiM Netherlands Institute for Transport Policy Analysis is responsible for studies on the VOTTS in the Netherlands. In their most recent study (Significance 2013), they found that the calculated VOTTS were lower than expected values even after correction for income. One of the explanation given for this finding is that people (especially train users) are able to use their time in a useful way which causes a reduction in their VOTTS although this has not been proven. Also, recent research on VOTTS in the UK (Arup, ITS, Accent,2015) concluded that the differences in VOTTS by mode reflect factors other than the possibilities for time use. They therefore recommended that a review on temporal stability of VOTTS should be made before drawing any conclusions.

This research will therefore serve as an empirical test for the above given explanation by checking how travelers' ability to perform certain activities during travel affect their VOTTS. From a policy aspect, the results of this research can help reshape the way the cost-benefit analysis for transport projects are calculated. Currently, the VOTTS used in national CBA appraisals do not take into account possible benefits of productivity and pleasantness of a journey in non-business trips.

1.2.2. Societal Relevance-What can NS and KiM do with this research

1) If the monetary value of different activities is calculated, NS can know how much they are currently adding to the society because they provide the opportunity for people to make productive and pleasant use of their travel time (with the current level of service).

2) Also in case of investment in the future, if the monetary value of different activities is known, then monetary gains due to investment in amenities that enables the performance of these activities can be calculated.

3) NS can introduce special sections in the trains for the most valuable activities eg. Library on the train for people who like reading books.

4) NS will know the comfort level required for different activities and what facilities are needed to perform the activities.

5) KiM can use the estimations of the monetary value of activities in the calculation of the value of comfort(VoC) derived from travel. This is because the comfort level on a train journey e.g. crowdedness, noise level, neatness of environment etc can have an effect on which activities can be performed.

6) KiM can use results from the value of activities in CBA calculations to correct for possible benefits derived from productivity and pleasantness of a journey.

7) Finally, it is of interest for both KiM and NS whether a decision to invest on increasing speed (i.e. actual reduction in travel time) is more cost-effective than an alternative decision to invest in the improvement of the journey experience (comfort, productivity and pleasantness of the journey). This research can provide the tools for a fair comparison of both decisions.

1.2.3. Scientific Relevance of research

In terms of quantitative research on the impact of activities of VOTTS, Ettema and Verschuren (2007) tested the hypothesis that multitasking (engaging in activities) during travel has potential effect on value of time(VOT). One limitation of this research is that it does not calculate the value of the activities. Also, no conclusion can be made concerning how valuable activities are to travellers. Based on their experiment alone, one cannot simply say there is a monetary value attached to the ability to read or listen to music during a journey because different people were compared.

Malokin et al (2017), have recently used the concept of willingness to pay(WTP) to evaluate the trade-off between the propensity to use laptop and either time or cost. The limitation of this research is that it calculates WTP for laptop and not for specific activity. For example, a laptop can be used for watching movies, reading, working or even listening to music, so the WTP for laptop does not tell us the monetary value of reading, or listening to music to a traveller.

Ideally, one should be more interested in the value of the activity and not the value of ICT devices. As technology improves, different ICT devices can be used for different activities eg. an iPad can be used for reading newspapers online, working, listening to music, watching a movie etc. Moreover, no matter the quality of service (quiet environment, WIFI, ability to seat etc) provided during the trip, you can't tell travellers what to do with the in-vehicle time. It is a matter of choice whether they engage in a particular activity or not. The best you can hope for is encourage them by providing an enabling environment for these activities. ICT and comfort level available enables people to perform various activities while travelling but it does not determine which activities people will engage in. Rather, it is the intrinsic value attached to these activities that determines what people will do with the available comfort and ICT available. This value is what this research will aim to estimate.

For example, a traveller can choose to work with his laptop on the way to work and then watch a movie with it on his way back home. The impact of these two activities on the travellers VOTTS could be different even though the equipment needed is the same. Using this example, it can be argued that ICT devices alone do not have an impact on VOTTS but rather, it is the specific activity which the ICT device is used for during the trip that has an impact on VOTTS. Given the reasons above, we opt to study the impact of certain activities on VOTTS instead of the impact of ICT devices on VOTTS.

There is currently no research that estimates the value of the activities performed during non-business travel. Also in terms of practical contribution, there is no available framework or guideline to include this travel behaviour in CBA. In this research, the limitations of previous research will be resolved. This will be done by comparing VOTTS for the same people in the same survey using the ability to perform activity as a context variable. In this way, the monetary value of activities can be calculated. Once this is done, this travel behaviour can be included in CBA the way other benefits like comfort, reliability, safety, environment etc. are being valued.

1.3. Thesis Outline

The thesis is organized as follows:

The present introductory Chapter presents the research problem, the objectives, and the scientific contribution of the thesis.

Chapter 2 gives a literature review of previous studies on the value of activities. The literature review focuses on both descriptive research and quantitative research on the topic.

Chapter 3 provides a detailed theoretical background of all methods and concepts used in the thesis. The chapter begins with a discussion on current method used to account for the productivity of a trip. This is followed by a discussion on time perception with activities. Finally, a method that can be used to calculate the monetary value of activities is presented. The goal of this chapter is to equip the reader with the required background knowledge necessary to understand the thesis and the results.

Chapter 4 presents the core research done in this thesis. It discusses in detail the approach used to arrive at final results. Specifically, this chapter describes the survey design. Also, a short description of the modelling techniques used, is presented to enable reader understand and interpret the results.

In Chapter 5, the results of descriptive data analysis and model estimation are presented and discussed. The goal of this chapter is to check if model results answer research questions and if they differ from expected outcome.

In Chapter 6, a summary of the findings of this thesis is presented. Also, a discussion on the possible impact and use of research result is presented. The chapter also reviews issues touched upon in the process of the thesis but still open for investigation and suggests possible directions of future research in the area.

To preserve the legibility and conciseness of the main text, some of the work done for this thesis is organized and presented in appendices. In particular:

Appendix A and B contains all the BioGeme and Ngene codes written for the purposes and used in producing the results of the thesis.

Appendix C contains the questionnaire used for getting data from respondents.

Appendix D contains other analysis results not shown in main text.

CHAPTER 2: Literature Review

2.1. Introduction

Studies on value of travel time savings(VOTTS) have traditionally focused on why value of time(VOTTS) could vary due to trip purpose, income, travel distance etc. However, studies that are specifically focused on variability in VOTTS due to the amount of travel time spent productive or pleasant are still very few compared to other types of studies on VOTTS. Thus, this literature review is limited to these types of studies in order to conform with the scope of this thesis.

Recently, research focus has shifted from the traditional way of treating travel time as a disutility with no benefits to a more practical way of viewing travel time as an opportunity for travellers to engage in various activities which could be beneficial to them. Pioneering this new research focus are the research published by Redmond and Mokhtarian (2001), and Mokhtarian and Salomon (2001). Specifically, Mokhtarian and Solomon contested the assumption that travel is a derived demand and therefore a disutility. The authors argue that travel can have positive utility which can be derived from three aspects. First, activities conducted at the destination, second activities conducted while travelling and the third is the activity of travel itself. They therefore questioned the validity of the traditional assumption that travel is a means to get to an activity location where the traveler can derive utility from undertaking that activity e.g. work, business meeting, shopping etc. Following this distinction made, the authors then defined as "excess" any travel not derived from the utility of the destination i.e. any travel made because of activities conducted during the trip and the activity of travel itself. The second element of travel (activities conducted during the trip) mentioned by the authors is the main focus of this thesis.

2.2. General review of research on activities and travel-based multitasking

Lyons and Urry (2005) have proposed that the "cost" of the time used for travel is reduced when some of the travel time is used for performing activities. That is, travel time is no longer seen as wasted time but can be made "productive" by engaging in activities. Their conclusion was that empirical evidence is needed to support the claim see. There is a growing number of research on this particular benefit of travel, so called travel-based multitasking (Ettema and Verschuren,2007; Malokin et al 2015; Berlinar et al 2015). See for instance (Keseru and Macharis,2017) for a comprehensive review of empirical evidence on travel based multitasking.

The search for empirical evidence has led to different types of research which are focused on four major aspects:

i. What activities people engage in during travel including whether they consider their travel time productive, pleasant or wasted (Lyons et al 2007; Watts and Urry 2008; Gustafson 2012; Gripsrud and Hjorthol; 2012 Lyons et al 2013; Mokhtarian et al 2015)

ii. The influence these activities have on mode choice (Malokin et al 2015; Frei et al 2015)
iii. Their impact on travel satisfaction (Ettema et al 2012; Frei et al 2015; van Hagen et al 2016)
iv. Their impact on VOTTS (Ettema and Verschuren 2007; Barnerjee and Kanafani,2008; Malokin et al 2017).

All research listed above each had some important findings about activities during travel. For example, Lyons et al (2007) reported that among 26221 rail passengers surveyed, reading for leisure (34%); window gazing/people watching (18%); and working/studying (13%) were the most popular activities and around 70% considered their travel time of some use and not wasted. Gripsrud and Hjorthol (2012) conducted a survey of rail travelers in Norway in 2008. The survey revealed that 35 % of commuters and 43 % of business travelers work on board while travelling by train and 25 % of people travelling for work-related purposes were equipped with a laptop. Interestingly, in this study, only 10 % of respondents said that their travel time is of no use which further questions the traditional assumption that time spent on travel is considered wasted. Still on this issue, there has been recent studies about the evolution of activities conducted during travel throughout the years. Most notable of those studies are, Lyons et al (2013) which compares rail travelers' activity behavior in 2004 to that of 2010. This type of comparison was also recently repeated in Lyons et al (2016) but this time making comparison was made between the years 2004,2010 and 2014. The main findings of the research were:

i. There is a shift from paper-based material to digital due to the development of ICT devices so passengers are more likely to be using e-books/tablets rather than newspapers and printed materials
ii. Although there was a significant increase of the percentage of people who considered their travel worthwhile from 2004 to 2010, this trend did not continue from 2010 to 2014 probably because of increased crowding.

With regards to impact of activities on satisfaction with travel, Mokhtarian et al (2015) found that performing an increased number of activities reduces the probability that the trip is considered tiring. Similarly, the research also found that a trip that involves talking to people is likely to be rated as pleasant while a trip that involves listening to music is less likely to be pleasant. This is somewhat surprising considering that in this same research listening to music was found to lower the chance of the trip to be classified as mentally fatiguing. Similar findings were also reported in Ettema et al (2012). This study investigated using the influence of activities on commuters' satisfaction with public transport using a satisfaction with travel scale(STS). The research found that talking to other passengers has the highest positive effect on satisfaction with travel. In contrast, activities like reading, listening to music lead to lower satisfaction. Their explanation for this is that people who engage in these activities are probably using it to "abate boredom". Also, a similar negative effect was found for users of mobile phones with the same explanation of using these

activities for abating boredom or "killing time". However, the authors cautioned that this result does not mean that removing these activities will lead to positive effect but that it might even lead to lower satisfaction. Similarly, Frei et al (2015) estimated a joint model of travelers' satisfaction and on-board activity engagement using data from Chicago transit riders. Their main finding was that activity engagement has "potential to influence travelers' VOTTS".

With regards to role of activities in pleasantness of a journey, their findings were in line with those of Ettema et al (2012) suggesting that ICT devices are used to prevent boredom or privatize public space. Regarding, the influence activities might have on mode choice, Malokin et al (2015) surveyed (N=2120) California commuters and used their response to estimate a revealed preference mode choice model which includes multitasking behavior. The aim of the research was to find out if the ability to engage in activities during a trip has an effect on the utility derived from travel on various modes. The authors found that engaging in productive activities like reading/writing or using a laptop/tablet has a significant impact on utility. They are also found that a "small but non-trivial portion of the current mode shares" could be as a result of opportunities offered by some modes to conduct activities e.g. rail. Their finding also seems to agree with that of Frei et al (2015) who reported that transit riders considered time and/or money spent on travel to be of better use than driving.

The conclusion from all the above research can be summarized as

i. There is evidence that people are using travel time as a means to conduct activities
ii. Not all travel time is considered wasted as it is currently assumed.
iii. These activities have influence on mode choice, travel satisfaction and possibly the VOTTS

2.3. Research on the impact of activities on VOTTS

In terms of quantitative research on the impact of activities of VOTTS, Ettema and Verschuren (2007) tested the hypothesis that multitasking (engaging in activities) during travel has potential effect on value of time(VOTTS). They postulated that travel time is valued less negatively (lower VOTTS) when it is used for other activities or become more pleasant. The stated choice experiment they performed showed that indeed people who disliked engaging in activities simultaneously during travel (monochromic individuals) had a higher VOTTS compared to those who likes engaging in activities. Interestingly when specific activities were examined, commuters who were listening to music had a lower VOTTS while those who were reading had a higher VOTTS," possibly because of a more task-oriented attitude". Their main conclusion was that multitasking has a significant impact on VOTTS and should not be ignored. One limitation of this research is that it does not calculate the value of the activities. Also, no conclusion can be made concerning how valuable activities are to travellers. Based on their experiment alone, one cannot simply calculate the value of reading because different people were compared. (Barnerjee and

Kanafani,2008) used utility maximization subject to time and money constraints to model the impact of being able to work during transit on the VOTTS of travellers. They showed using numerical example that a wireless connection which enables travellers work during transit with 80% efficiency compared to the office, can reduce VOTTS from 30 to 4 money-units/time-units. The difference between these two VOTTS is then characterised as the value of wireless internet connections of trains. The limitation of this research is that it calculates the value of wireless connection and not of activities. Although WIFI is needed to work, it can also be used for other activities such as watching movies, listening to music etc. Another limitation of the research is that it assumes a linear relationship between efficiency of working and the reduction in VOTTS. So, at efficiency of 100% the VOTTS is theoretically zero. This of course highly unlikely since there is always an initial resistance to travel. So, the VOTTS even with the presence of WIFI still needs to be calculated empirically.

Recently, Wardman and Lyons (2015) have revisited the issue of effect of performing activities while travelling on the VOTTS. They argue that although performing activities does not reduce travel time, it reduces the disutility of travel time because travellers are able to make worthwhile (productive use) of their travel time. The authors support their claim by stating that clock time is different from experienced time. That is a traveller might experience the time he spent travelling differently (stretched or compressed) depending on his state of mind (relaxed or stressed) or the way the travel time is used. In fact, this idea put forward by the authors is actually well studied in literature of time perception (see for example the work of Van Hagen (2011) for more details on this. Van Hagen in his dissertation on waiting time experience, explains using reversal theory and time psychology, that when people are bored, time passes more slowly but when people are relaxed and able to enjoy their journey, time passes more quickly. In an experiment conducted on waiting time experience on train stations, the author found that on average passive people who didn't engage in any activities while waiting perceived time to go slower thereby overestimating how much time they have waited (van Hagen 2011, pp.68). This theory of time perception offers further evidence that activities could indeed have a significant impact on how people value travel time at least from the emotional point of view.

Given the limited research on how activities influence value of time, it is no surprise that this travel behaviour is currently being ignored in estimations of VOTTS for use in national CBA. A review of VOTTS studies from various countries by Wardman and Lyons (2015) revealed that worthwhile use of travel time is not explicitly accounted for. The only exception being for business travel, the time spent working is considered productive and some studies use the Hensher equation (Hensher 1977) to account for this. Recently, Hensher and Wang (2016) show how to use the Hensher equation for productivity foregone and leisure time corrections of the value of business travel time savings. The parameters of the equation were estimated from various national studies on how travel time is used for business travellers. In their research, the authors explicitly state that the productivity corrections are not applicable for commute and private trips. This is because it is assumed that this is captured by the utility maximization models currently being used for estimation of VOTTS for non-business travel even though this has not been empirically proven by any research.

For instance, Malokin et al (2017), have recently used the concept of willingness to pay(WTP) to evaluate the trade-off between the propensity to use laptop and either time or cost. Using a revealed preference mode choice model, they measure how much commuters are willing to pay for the ability to use a laptop, i.e. for productive multitasking. This "propensity to use a laptop" depends on the possibility that a laptop can be used on this mode and also on the traveller's desire to use the laptop during the trip. The study examined multitasking travel behaviour between millennials and non-millennials. The main finding from the study is that millennials have lower VOTTS partly because of their preference for travel-based multitasking. Specifically, the research showed that millennials value ICT usage more and have a higher WTP for laptop compared to non-millennials. This result is an indication that even for non-business trips like commute, the ability to be productive during travel is also considered and thus might influence their value of time. For example, they might be willing to opt for a cheaper and longer trip if they can use their laptop during the trip.

2.4. Thesis research directions based on literature review

In this research, we argue that since all trips regardless of trip purpose can be spent productively or pleasantly depending on the traveller, possible corrections should be made to current VOTTS. However, to determine how much corrections should be applied, one needs to correctly model and measure the impact of travel-based multitasking on VOTTS. To the best of our knowledge, no practical model of such exists and this thesis intends to fill that gap. Warffemius et al (2016) have estimated that comfort benefits related to travellers being able to spend their travel time in a useful way can be worth around €1billion euros per year for the Netherlands. This value was based on rough estimates calculated from combining data from various sources like Dutch Railways(NS) passenger survey, VOTTS studies for the Netherlands and Mott McDonald (2009) et al studies on reduction of travel time savings due to time spent in a useful way. Although the value presented above is a rough estimate based on some assumptions, it shows that if the value of travel time spent in a useful way can be correctly estimated, then the monetary benefits of public transport projects like those meant for improving the opportunity for and the quality of worthwhile use of travel time can be calculated. It is noted that the currently available research only considers the impact performing in-vehicle activities have on public transport satisfaction (Ettema et al 2012), public transport service value (Frei et al,2015;Van Hagen et al 2016), VOTTS (Ettema and Verschuren,2007; Banerjee and Kanafani,2008; Malokin et al 2017).

There is no research that explicitly estimates the value of the activities performed and also do not provide a method or model to make correction to the VOTTS of a productive or pleasant journey. Finally, there is no available framework or guideline to include this new travel behaviour in CBA. For clarification, it is noted that the research of Ettema and Verschuren (2007) does not also explicitly estimate the value of activities because they only used dummy variables to represent whether or not activities were performed and they compared VOTTS of people who were engaging in activities like reading or listening to music to people who were not. As pointed out in Wardman and Lyons (2015) it is not sufficient to compare VOTTS across activity patterns of different people because it may

have a counter effect that those who are engaging in some activities may have higher VOTTS compared to others. This does not mean that the activity has no positive value but maybe for other reasons. For example, Wardman and Lyons state that one reason could be that "those who have more important uses of travel time or for whom the 'boredom' of 'no activity' is greater will be more inclined to ensure that they have such things to do on the journey". This could be the reason why Ettema and Verschuren (2007) reported a higher VOTTS for people reading compared to people who didn't. As stated earlier, based on the type of survey conducted in Ettema and Verschuren (2007), no conclusions can be made as regards the value of activities. Also, the research of Malokin et al 2017, only calculates WTP for laptop and not for specific activity. For example, a laptop can be used of reading, working or even listening to music, so the WTP for laptop does not tell us the monetary value of reading, or listening to music to a traveller. As discussed in the introduction, one should be more interested in the value of the activity and not the value of ICT devices. As technology improves, different ICT devices can be used for different activities. This limitation is also true for the research of Banerjee and Kanafani (2008) who calculate the value of wireless connection. What is common in all the previous research is that they all tend to agree that performing activities while travelling may have an impact on VOTTS.

Therefore, the goal of this research, is to measure this impact and attempt to explicitly estimate the monetary value of these activities using specially designed survey for this purpose. The experiments, follow the advice given by Wardman and Lyon (2015) that research on estimating the value of activities would have to control for it by presenting people with survey that involves "removing or diminishing the ability to undertake worthwhile activities while travelling". This will enable us to directly calculate the impact these activities have on traveller's VOTTS.

CHAPTER 3: THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1. Introduction

This thesis will focus on work and non-work-related activities performed during non-business trips i.e. commute and leisure trips. The VOTTS for these types of trips are usually calculated from SP surveys and currently, they do not explicitly consider productivity or pleasantness of a trip on the travellers VOTTS. The question of whether or not these activities affect the VOTTS needs to be answered. To do this, it is important to understand the rationale behind this type of travel behaviour. This will enable this behaviour to be correctly modelled and accounted for in VOTTS estimations. In the next sections, we discuss the current frameworks used to account for activities and thereafter introduce a new survey method that can be used for calculating the monetary value of different activities.

3.2. Current Framework for valuing activities

3.2.1. The Hensher equation

The Hensher equation (Hensher,1977, Fowkes et al 1986) is the first to account for productivity during travel. This equation is only valid if the trip purpose is business and the activity performed during the trip is work-related. For other trip purposes and non-work activities, there is currently no similar practical model for that. Recently, (Pawlak et al 2014) have developed a microeconomic framework for modelling the joint choice of activity–travel behaviour and ICT use. However, the complexity of the model has limited its use in practical application. The Hensher equation is still the most practical method used for representing productivity during travel. The equation is described below:

$$V_{BTTS} = (1 - r)MPL + rV_L - pqMPL \ \textit{(The Hensher Equation)}$$

Where

V_{BTTS}= Value of business travel time savings(euros/hr)

MPL=Marginal Product of Labor (Wage rate) also in (euros/hr)

V_L = The way you value your private leisure time (according to current practice) also in (euros/hr).

r=Proportion of travel time savings used for private leisure activities

p=proportion of travel time spent on work

q=ratio of comparison when work is performed at preferred location(office) compared to during travel

Although, the Hensher equation did not have any theoretical foundation in the beginning, it has recently been shown that the equation can be derived from first principle using the theory of time allocation (Batley,2015; Kato, 2013). The theory is described in the next section.

3.2.2. The theory of time allocation

The theory of time allocation as put forward by (De Serpa ,1971) assumes that there are a set of goods(activities) to be consumed and each good require a minimum amount of time for consumption and a certain price. The amount of goods to be consumed and the time to be spent on the consumption of the goods is constrained by a budget(income) and by the total amount of available time. Since utility is derived from the consumption of these goods, a rational individual will try to maximize his utility by efficiently allocating his time and money to the consumption of certain goods. Using this framework, De Serpa gave three types of value of time. First, the value of time as a resource which describes how much more income will be earned if total time available time was extended. Second, the value of time as a commodity which is the value derived from assigning time to a certain activity. The third is the value of saving time in a certain activity. This is defined as the difference between the resource value of time and the value of time as a commodity. If in this model, the competing goods are travel, work and leisure, then the third definition corresponds to the VOTTS if the activity is travel. That is:

VOTTS=Resource value of time-value of allocating time to travel

As can be seen from the equation above, the VOTTS will reduce if the value of allocating time to travel is positive, in other words, if travel has some positive benefits then one would gain less in saving travel time but rather would prefer to extend it. This suggests that the assertion made by (Mokhtarian and Salomon,2001) about excess travel is correct to some extent. In essence, one would be inclined to travel longer because he is receiving some positive benefits from travel. The next step now is how to estimate the positive benefits of travel. To do this some definitions for VOTTS are presented in the next section.

3.3. New definitions for VOTTS

Travel is traditionally seen as a derived demand i.e. one travels in order to partake in activities such as work, business meetings, shopping etc. So typically, travel time is considered wasted time which should be reduced. Following the traditional belief that travel time is a disutility, the following types of VOTTS are defined:

I. ***The value of unproductive or unpleasant travel time savings(VOUPTTS)***: This VOTTS is the one that will be estimated if a trip was to be made without engaging in any activity that makes the journey pleasant or productive. This would be the pure VOTTS where the travel time is considered wasted.

II. ***Value of productive or pleasant travel time savings (or VOPTTS)***: This VOTTS is the one that will be estimated if a trip was to be made productive or

pleasant by engaging in one or more ***preferred activities of choice*** during travel.

Note that it is important to make this distinction between VOTTS because currently it is not known to what extent activities performed during trip, affect VOTTS. If activities performed during travel do not have an impact on VOTTS then these two definitions above are essentially the same.

Using these two definitions above, we can conceptualise the difference between these two VOTTS as the monetary value, V_A (in euros/hr) of the activities. It is expected that the VOUPTTS will be greater or equal to the VOPTTS. The hypothesis is that people will only engage in activities either just to kill time (i.e. no value) or because they derive value from it.

$$V_A = VOUPTTS - VOPTTS \quad (1.1a)$$

Note that it is possible that a traveller might be engaged in an activity because they have no option (e.g. someone working on a commute trip because they have to meet a deadline and not because they prefer it.) In this case the value of the activity could be negative. This is highly unlikely but could happen.

Given these definitions, the question that immediately comes to mind is how the monetary value of an activity differs from the willingness to pay (WTP) to engage in that activity. This is addressed in the next section

3.3.1. Willingness to pay(WTP) and Value of activities V_A

The value of the activity V_A as calculated in equation 1.1a, slightly differs from a willingness to pay(WTP) to engage in the activity. It is necessary to make this distinction to avoid a misinterpretation or misuse of values. The major difference is that it not necessarily constrained by a budget because there is no actual trade-off (i.e. between a productive journey with activity at a higher cost versus an unproductive journey with no activity at a lower cost). It is just a simple self-evaluation of VOTTS under different circumstances. So, for example, a person with a higher income who likes music will have a higher willingness to pay to listen to music but does not mean that the value derived from listening to music will be higher than someone with a lower income (think of the value as the utility derived from listening to free music). In fact, it could happen that a traveller is not willing to pay at all to listen to music during travel but he considers listening to music a free gift and the most useful way of spending his travel time which he already paid for with his money. Another more convincing example is the passive activity of "looking outside" or "enjoying the view". Travellers might not be willing to pay to look outside and enjoy the view, but they attach a value to it.

The difference in the VOTTS with and without activity is related to the way the travel time is perceived by the traveller. So, while doing a preferred activity it is expected that the traveller values time less negatively (i.e. more enjoyable) compared to doing nothing or something else. That means they are willing to pay less to reduce a "productive/pleasant" travel time and willing to pay more to reduce an "unproductive/unpleasant" travel time. This behaviour is partly explained by time perception theory. The theory is discussed below

3.4. Linking value of activities with time perception theory

The theory of time perception shows why activities could have value to the traveller. This theory makes a distinction between experienced travel time and clock travel time. That is a traveller might experience the time he spent travelling differently (stretched or compressed) depending on his state of mind (relaxed or stressed) or the way the travel time is used (Van Hagen 2011; Watts,2008; Wardman and Lyons 2015). Van Hagen in his dissertation on waiting time experience, explains using time psychology (Zakay ,1989) and reversal theory(Apter.2007), that when people are bored, time passes more slowly but when people are relaxed and able to enjoy their journey, time passes more quickly. In his experiment conducted on waiting time experience on train stations, the author found that on average passive people who didn't engage in any activities while waiting perceived time to go slower thereby overestimating how much time they have waited (Hagen 2011, pp.68). This theory of time perception offers further evidence that activities could indeed have a significant impact on how people value travel time. Using the diagram below, Van Hagen explains that when people find themselves in a comfort zone, they are happy and relaxed and time is experienced faster. In contrast, when they are stressed or bored, time will pass slowly.

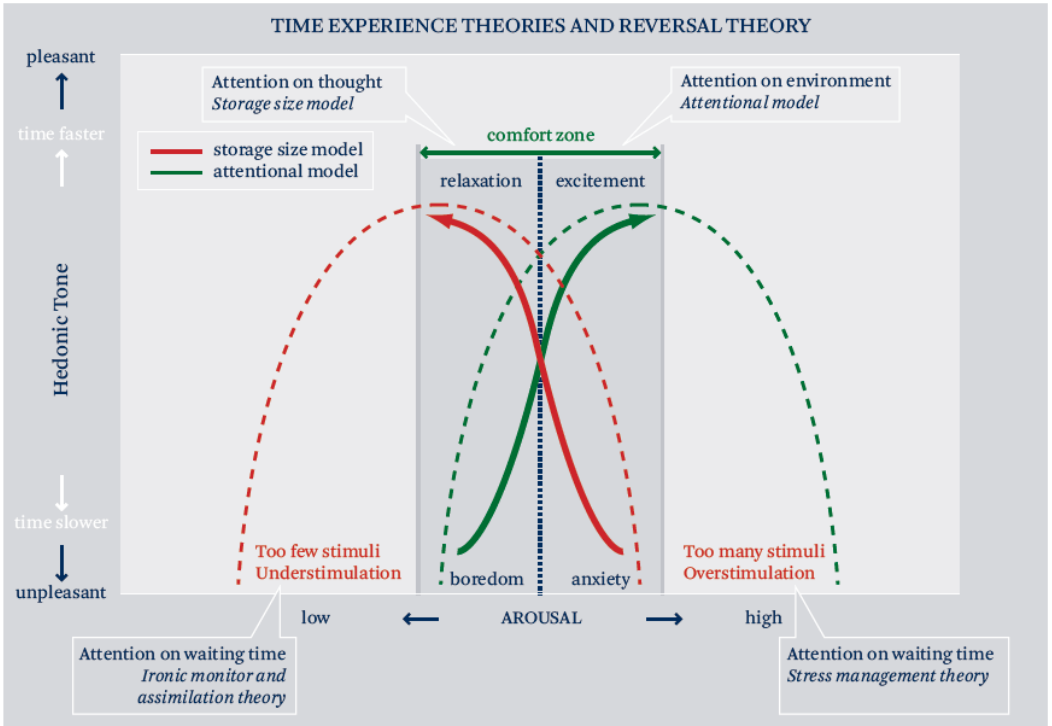

Figure 3-1 Conceptual Framework of How time is perceived (Source, van Hagen,2011)

Since time is money, it can be argued that if the travel time is stretched (feels longer than actual) then the traveller might feel that "some value is lost" and if the travel time is compressed (feels shorter than actual) then traveller feels that "some value is gained". So, the monetary value of an activity could be related to how much shorter the travel time is perceived when engaging in that activity during the journey.

3.4.1. Linking value of activities with door-to-door appreciation of travel time

In his dissertation, van Hagen also makes a distinction between trip time and how this time is valued (experienced) by the traveller. In his illustration, trip time is represented on x-axis and the experienced time is represented on the y-axis. The x-axis represents the effort a traveller has to make in order to engage in certain activities e.g. work, partake in a business meeting, shopping etc. The y-axis represents the utility experienced because of engaging in certain activities during the trip (work, read etc) or the utility derived from a pleasant trip. As shown in the figure below, the time the traveller spends at the origin and destination is appreciated most. This is because these are the two most likely places to spend time in a useful way (e.g by engaging in activities) .

In contrast time spent in waiting or transfer is the least appreciated again because waiting time is the least likely to be spent in a useful or pleasant way, this has been consistently reported in literature (see, Wardman et al,2004). Of all parts of the trip time, the in-vehicle time seems to be the most appreciated one because it gives better opportunities for traveller to spend their time in a useful way.

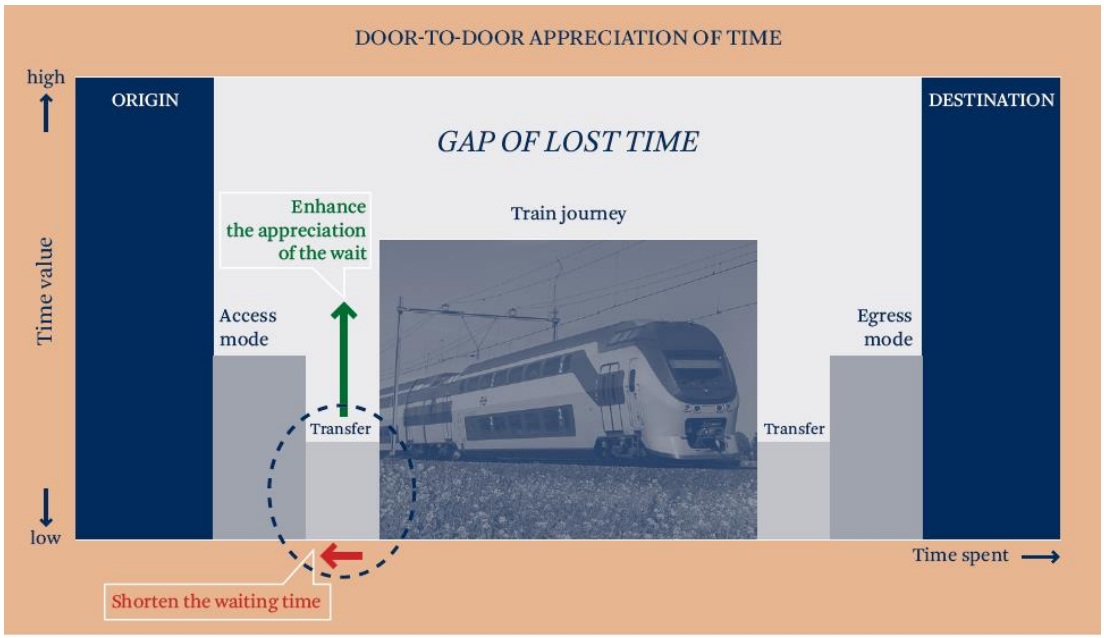

Figure 3-2: Appreciation of time: source, van Hagen,2011

As the figure above shows, there are some gaps in lost time due to low appreciation on the y-axis and also due to increased time spent on travel on the x-axis. This gap can be reduced by either increasing travel speed, frequency of connections or by making the trip time more pleasant or productive to increase its appreciation. Traditional approach has always focused on the former (making the trip faster) but perhaps a better approach would be to focus on the latter (making the trip more pleasant or productive for the traveller).

It is easy to calculate the monetary gains from an investment that physically reduces travel time. However, as we discussed in the previous sections, it is possible that travel time is perceived shorter than actual when a traveller is engaged in an activity. The monetary gain from this "reduction" in travel time due to activities are not currently valued as it is done for speed. In the next section, a special type of experiment which can be used to calculate the monetary value of activities performed during travel is proposed.

3.5. The self-engagement experiment: A methodology for valuing activities.

The hypothesis for this thesis is that when you are engaging in activities during travel, you might value travel time differently (e.g perceive it shorter than actual) than when you are just being idle (even though you don't realize it and might even not be willing to pay for it). For example, someone listening to music during travel might enjoy the trip more and perceive his travel time shorter but does it make sense to say he is willing to pay to listen to music or does he already consider being able to make use of his travel time the way he wants a personal choice?

The dilemma is: how can we model this type of behaviour and estimate the (intrinsic) monetary value of an activity to a traveller? To do this, some special surveys need to be carried out to model the impact of activities on VOTTS. Some examples of such experiments are described below

3.5.1. Pure Self-engagement experiment (No activity combined with travel)

Suppose we perform a simple real-life experiment to calculate the value of time of a traveller during his journey.

Experiment 1a: the traveller is subjected to travelling during which he is not able to perform any productive or pleasant activity **and thus does nothing**.

Experiment 1b: the traveller is allowed **to perform any activity *A* of choice during the journey**.

After each experiment, the VOTTS for the traveller will be estimated for both scenarios. Now there are three possible outcomes.

1) The ***VOTTS for both experiments are equal*** meaning the activity *A* does not play any role in the value of time of the individual.

2) The ***VOTTS of experiment 1b is less than VOTTS of experiment 1a***. This means that performing activity A results in a reduction on the VOTTS. In other words, the disutility of travelling is reduced
3) The ***VOTTS of experiment 1b is greater than VOTTS of experiment 1a***. This means that performing activity A results in an increase the VOTTS. In other words, the disutility of travelling is increased.

The difference in VOTTS of experiment 1a and experiment 1b is defined as:

$$V_A = VOTTS_{1a} - VOTTS_{1b} \quad (2.1a)$$

This difference can be characterized as **the total monetary gain or loss** (per unit time) from engaging in activity A during the journey.

The experiment described above calculates the maximum value derived from activity A during the journey. The advantage of this experiment is that it can calculate the full value of every activity. If there exist a finite number of activities, then the values of each of the activities can be compared to know which one has the highest value to the traveller. So, the experiment will have to be repeated for all activities. In real life however, there are a lot of activities a traveller can engage in which makes it difficult to know which one is the most important to the traveller. So, it will be difficult to know which activities have the most value to the traveller by this experiment. In the next section, we circumvent this problem by allowing the traveller to pick from a list of possible activities, the most preferred one. The modified experiment is described below:

3.5.2. Self-engagement experiment without preferred activity

Experiment 2a: the traveller is subjected to travelling during which he is not able to perform a preferred activity A and thus **does something else**.

Experiment 2b: the traveller is allowed to **perform preferred activity *A*** during the journey.

After each experiment, the VOTTS for the traveller will be estimated for both experiments. Now there are three possible outcomes:

1) The ***VOTTS for both experiments are equal*** meaning the preferred activity A does not play any role in the value of time of the individual i.e. both activities have equal or no impact on VOTTS.
2) The ***VOTTS of experiment 2b is less than VOTTS of experiment 2a***. This means that performing activity A results in reduction of the VOTTS of the individual. In other words, the disutility of travelling with activity A is less than the disutility of travelling without activity A .

3) The ***VOTTS of experiment 2b is greater than VOTTS of experiment 2a***. This means that performing activity A results in an increase in the VOTTS. In other words, the disutility of travelling is increased when combined with activity A.

The difference in VOTTS of experiment 2a and experiment 2b is defined as

$$V_{A\_preferred} = VOTTS_{2a} - VOTTS_{2b} \quad (2.1b)$$

This difference can be characterized as the **extra monetary gain or loss** (per unit time) from engaging in activity A during the journey compared to doing something else.

In this experiment, one can easily tell if the preferred activity is the most valuable one. The intuition is that if all activities have the same monetary value their impact on the value of time of the traveller should be the same. So, the traveller can basically choose any activity at random as long as he/she is not idle. In this regard, this experiment can be used to determine which activities have extra monetary value to travellers during a trip.

Hypothesis

If a traveller chooses activity A as their preferred main activity during a journey, then the monetary value of that activity is non-negative. i.e. $V_{A\_preferred} \geq 0$

The hypothesis above means that a rational traveller will not choose a preferred activity that increases his original VOTTS. So, the initial VOTTS will either stay the same or reduce. If it stays the same, then the preferred activity has same value with another activity or no value at all (i.e. used for killing time). If the initial VOTTS is reduced, it means that the preferred activity has an added value compared to other activities.

3.6. Self-engagement experiment in real life setting

The self-engagement experiments described in the previous section, are carefully designed to avoid any bias in results. That means, the difference in the VOTTS between scenario of no activity and activity is clearly due to conducting activity alone and nothing else. All conditions are kept the same and the traveller is the same. This means that there is no reason that the VOTTS of the traveller should change significantly except if he attached a monetary value to the activity. In terms of accuracy, the described experiments are the most accurate ones. However, in terms of feasibility there are some difficulties expected.

- Travellers need to be subjected to a journey where they are not able to perform any activity or not able to perform their preferred activity thus making the trip very boring (as expected). This is against the company policy of NS of ensuring that they provide the best travel experience possible.

- If people are paid(recruited) to participate in this survey it can introduce some bias in the results since they will not actually be in that situation but just voluntarily.

Given the problems listed above and also the difference between the first and second experiment it is more feasible to design a stated preference(SP) equivalent of the self-engagement experiment without preferred activity. This will enable the estimation of the value of certain preferred activities by measuring their impact on VOTTS. The self-engagement experiment with no activity at all was not chosen because it is difficult for people to imagine a journey where they cannot perform any activity during their journey without introducing bias related to the train environment.

Note that using a hypothetical SP survey instead of an actual revealed preference might bias results (i.e. activities could be undervalued or overvalued). This is because people are not actually making the journey without doing their preferred activity. So, it is difficult for them to feel the boredom or discomfort associated with the new situation. In order to reduce this bias, the context needs to be carefully explained to respondents to help them better imagine the situation.

In the next chapter, the actual survey design used to calculate the values of activities is explained in details.

CHAPTER 4: SURVEY DESIGN AND ANALYSIS TECHNIQUES

This chapter describes the actual survey design and analysis techniques used for obtaining results.

4.1. Set up of experiment

A hypothetical stated choice equivalent experiment was designed to calculate the value of activities. In this experiment travellers are asked to imagine they forgot what they need to perform certain ***preferred main activities***, hence they are not able to perform the intended activity throughout the journey (but can still perform other activities). Also, ***the same travellers*** are asked to reimagine that they have all they need to perform the activity and hence can perform the activity for the whole journey. It is important to note that the context was changed and not the respondents. This is a very crucial step in the experimental set-up. So instead of comparing VOTTS of the different people across different activities (as done in other research, see Ettema and Verschuren 2007), ***we compare the VOTTS of the same people with same preferred activities but vary the context with and without the activity.*** This enables the direct calculation of the value of the preferred activity for those people.

The respondents were first asked general questions about the characteristics of their most frequent trip when using the train. These include trip purpose, frequency of trip, conditions relating to the train environment (noise, crowding, seat availability), preferred main activity type etc. After this, respondents are presented with the SP survey based on the activity selected and the equipment needed for the activity.

4.1.1. Selection of trip purpose of focus

The trip purposes of focus are commute and leisure trips. These two purposes were chosen because they make up about 76% of all trips (34% commute and 41% leisure) by NS trains(NS,2014). Another reason for selecting these two trip purposes was that the current VOTTS for these trip purposes are usually calculated from SP surveys without explicitly taking into account the productivity and pleasantness of the journey. In this research, the VOTTS that will be calculated will take into the account the activities conducted during the trip. This will enable the comparison of the current VOTTS to the ones found in this survey.

Note that respondents with other trip purposes were not excluded from the survey. This is to enable NS get other information regarding these trip purposes.

4.1.2. Selection of preferred activities of focus for SP

For activities that do not require special equipment e.g. looking outside, relaxing, sleeping, it was not possible to describe the context where the activities cannot be performed. For example, telling someone they can't relax or sleep on the train could be interpreted to mean that the train is noisy, crowded etc. This introduces bias in the pure value of the

activity because respondents are now also valuing crowding, noise etc which is not the focus of this study. To avoid this bias, it was decided to exclude respondents who did not require equipment for their activities from the SP survey. Note that these respondents were not excluded from the non-SP part of the survey this is to enable NS get some other valuable information concerning these types of activities.

All other activities were included in the SP. However, the main focus of the thesis was on three activities, reading, working and listening to music. This was based on the need of NS, the popularity of these activities based on previous studies and also based on the characteristics of the activity (i.e. whether productive or pleasant).

Specifically, reading was chosen based on popularity. Recent studies by (van Hagen et al,2016) showed that around 28% of travellers on the train are reading on the trip. This was the second most popular activity after "looking outside" which was 34%. This is also in agreement with other findings in previous research (see Lyons et 2007) where around 34% of train travellers in the UK are reading for leisure.

The next activity selected is working/studying. The activity working was selected because it is a clearly productive activity with a possibility of getting physical monetary compensation for it. Also working is fairly popular among commuters using NS trains with around 10% working during the trip (van Hagen et al,2016). Also, a study of by Gripsrud and Hjorthol (2012) showed that 35% of train commuters in Norway work during their trip.

The third activity of focus is listening to music. Although not as popular as reading, around 20% of travellers by NS trains listen to music during the trip and they consider it a pleasant activity (van Hagen et al, 2016). Selecting the activity "listening to music" will enable the comparison of the values of a classic productive activity like work with that of a classic pleasant activity like listening to music. Finally, previous work by (Ettema and Verschuren ,2007) have already compared the VOTTS of those reading to those listening to music and found lower value for those listening to music. So, selecting the activity "listening to music" will enable comparison of this study with theirs as well.

4.1.3. Final Segmentation for analysis

Given the trip purpose and activities of focus in this research, the following segmentation was made:

Table 4-1: Segmentation of respondents

Commute	Leisure
Commuters who read	Leisure travellers who read
Commuters who work	Leisure travellers who work
Commuters who listen to music	Leisure travellers who listen to music

For these six segments, the values of activities will be calculated.

4.1.4. Assigning activities to respondents

Most respondents have different outbound and inbound activity. For instance, previous studies revealed that around 32% of travellers were reading on outbound trip compared to 26% on the inbound trip. This is also true for working which drops from 10% on outbound trips to 8% on inbound trip(NS,2014). This makes it hard for respondent to choose a preferred main activity (i.e. the activity the respondent normally spends the most time on during the journey). To avoid this problem, respondents are allowed to pick one main activity during the outbound trip and another one during the inbound trip (if it is not the same). After this, the respondents are assigned a particular trip (outbound or inbound) with the corresponding main activity. So, based on the focus of the research and the difference in outbound and inbound activities, the following rules were used to assign respondents to activity:

1. If outbound activity is any of reading, listening to music or working and inbound activity is different then, randomly choose reading working or listening to music for this respondent
2. If the any of the activity is working or listening to music (outbound or inbound) then randomly choose working or listening to music for this respondent. Note this rule was used to increase the number of respondents who will do the SP survey with and without these activities. In a previous pilot reading was assigned to too many people while working and listening to music had very few respondents.
3. If the activity (outbound and inbound) is neither reading, listening to music nor working, then randomly assign respondent to one activity

Note that although other activities were not of interest in this thesis, they were not excluded from the SP. This is to enable NS to use information, data and other questions relating to these activities for future research.

4.2. Recruitment of respondents

The respondents used for the survey were selected from the Netherlands Railways(NS) panel. This panel consist of train travellers (around 60,000) who voluntarily agree to take part in regular surveys conducted by NS regarding travelling by train. The choice to use the NS panel for this study was motivated by the focus of the research which was on activities performed during travelling by train. The respondents are familiar with the train environment and what activities they can perform during the trip. This makes it easier for them to understand the survey. Also, the respondents were not compensated in any form to participate in the survey so this reduces bias of respondents deliberately trying to help researcher. All surveys were filled in online by respondents which made the collection of data easier.

4.2.1. Pilot design

Since this type of survey is relatively new, it was decided to first do a pilot in order to see how respondents answer the survey questions, do some preliminary estimations to get an indication of results and to use the priors of the pilot to design the main survey. A total of 1500 participants were sent the pilot survey and 531 people completed the survey.

The pilot survey showed some promising results although no conclusions could be made yet because of the poor model fit and the small number of respondents per activity. However, the results and experienced gained from the pilot survey were used to improve the main survey design. For example, the rating of the pilot survey by respondents was 5.3 out of 10 while that of the main survey was 6.7 out of 10. This indicates a better understanding of the main survey compared to the pilot.

The main survey design is described in the next section including the changes made to the original pilot design.

4.3. Main Survey Design

4.3.1. Number of respondents and sample characteristics

Around 6000 people were sent the main survey and 1558 completed the survey (Response rate of about 26%). For the activities of interest reading, working and listening to music, 820 respondents completed the SP using the rules described in 4.1.4 (about 53% of all respondents). The remaining respondents completed the SP for other activities.

Table 4-2: Number of Respondents for activities of interest

	ALL RESPONDENTS(N=1558)			
Activity	Commute(N=540)		Leisure(N=739)	
	Outbound	Inbound	Outbound	Inbound
Reading	212	153	369	304
Working/Studying	101	73	29	22
Listening to music	35	44	46	51
Total	348	270	444	377
Final SP total	384		436	

Table 4-3: Background data of all respondents

Background Variables(N=1558)		
	Actual(NS,2014)	Survey
Gender		
Male	51%	52%
Female	49%	48%
Age		
18 to 24	11%	12%
25 to 34	15%	14%
35 to 44	17%	15%
45 to 54	19%	15%
55 to 64	16%	16%
65 to 74	13%	12%
75 and older	9%	16%
Ticket		
Fully paid by respondent		57%
Partially paid by employer		12%
Fully paid by employer		20%
Others		10%
Trip Purpose		
Commute	34%	35%
Leisure	41%	45%
Others	25%	20%
Income		
Below average		27%
Average		25%
1-2 times the average		26%
More than twice the average		10%
Don’t know/Don’t want to tell		12%

Gender and Age distribution

The gender distribution is almost even with just slightly more males than females. The percentage distribution of gender is almost the same with the actual distribution using the most recent data from NS(NS,2014).

Also, the age distribution is evenly spread too with all age groups from 18 years and older represented. Again, the distribution of respondents in the survey closely matches the current age distribution of travellers by NS trains although the number of people older than 75 is slightly higher.

Ticket Payment

The actual percentage of people who pay for the whole ticket themselves (i.e. with no subscription) is around 67% according to the latest NS data. In this survey, around 57% of people pay themselves which is reasonably close to the actual percentage. Note that the payment of ticket can affect VOTTS especially for those who do not pay at all. Fortunately, the percentage of people who do not pay is small compared to those who pay. Also, this is explored in analysis to check for any effect on VOTTS.

Trip purpose

The target trip purpose commute and leisure are both well represented. There is only a small variation between actual distribution of travellers by trip purpose. This is good since the analysis in this thesis will focus on commute and leisure trips. These trips make about 75% of the current trip made using NS trains(NS,2014).

Income

Asking respondents about income is usually not well received by members of the NS panel. However, an attempt was made to get some information about their income. The income levels were deliberately asked in very vague manner in order to encourage respondents to fill in without extra pressure. Also, the question about income was asked last to avoid any bias by respondents. The first three income categories are evenly spread around 25% for each class. This might be due to the similarity of the classes to the average income rather than being the actual income distribution. Unfortunately, there is no way to compare this information to actual income distribution of NS travellers since this is not normally asked. As expected income levels of more than twice the average income clearly differs from the rest. This is reflected in the percentage of respondents within that income range (around 10%). Again, this percentage is not verifiable. However, income is still used as interaction variable with VOTTS to test any possible influence.

4.3.2. Selected attributes of choice experiment

Travel cost: This is the total cost of the journey in euros. This reflects the usual way of travelling by train in the Netherland where cost for the whole journey is deducted at the end of the trip.

In-vehicle time: This is the total travel time spent inside the train in minutes. This enables respondents to understand how many minutes they will spend with or without being able to perform their preferred activity.

Excluding all other attributes

It is well-known that the travel choices people make do not only depend on time and cost only. Of course, there are other attributes like transfer, preferred departure time and arrival time, frequency, comfort, reliability etc. However, for the purpose of this research we keep all attributes of the train journey constant and examine the impact of activities on the time and cost attributes only (i.e. the VOTTS). The survey is designed in such a way that respondents assume normal travel conditions.

What we want to measure is the pure value of activities assuming that the traveller has already considered all other travel attributes. Although it is unrealistic that only cost and time are considered, it is a valid assumption for the research question this thesis is meant to answer.

4.3.3. Number of alternatives

The pilot design had three alternatives. However, for the main design we opted to use only two alternatives. The main reason is to reduce the complexity of the choice tasks and enable respondents to easily make choices. In the pilot, a lot of respondents found the SP survey difficult to understand and the use of three alternatives further complicated the issue. This resulted in a poor model fit close to a random selection. The use of two alternatives only, helped to reduce randomness in choices and improve model fit. The main disadvantage of using two alternatives is that the extra information gained from the trade-off with a third alternative is lost. Also, more realistic choice models like random regret models (Chorus et al 2008, Chorus ,2010) which capture compromise effect, reference dependency etc, cannot not be used as they require at least three alternatives. Again, for the purpose of this research, it is justified to use only two alternatives since we are more interested in the change in the VOTTS due to the context and not necessarily a change in the decision-making rules of respondents.

4.3.4. Number of choice sets

The pilot survey used 4 choice sets but considering that the number of alternatives was reduced from three to two, the number of choice set was increased from 4 to 6 choice sets. This enables us to compensate for the information loss due to the reduced number of alternatives. In total respondents answered 12 choice tasks. 6 choice tasks with the ability to

perform their preferred activity and another 6 choice tasks without the ability to perform preferred activity. The small number of choice task was chosen to keep the time for answering the full survey (questionnaire and SP) within 10mins which is the time limit set by NS for all surveys using respondents in its panel.

4.3.5. Using non-dominant choice sets

All six choice tasks for both context did not include dominant choices in terms of time and cost. The removal of dominance was automatically done in the design using Ngene (Choice Metrics,2012) and not manually. So, the most efficient non-dominant design was used. This is because adding dominance test can lead to unfairly removing respondents who fail the dominance test and this could affect the balance in the number of respondents in each context (with and without activity). For instance, in the pilot survey, more people failed the dominance test in the context with activity compared to the context without activity. When people are removed, distance classes could become unbalanced and also the number of respondents is unbalanced making it difficult to compare the VOTTS of the two contexts. Another reason is that the presence of dominant alternatives can lead to significantly biased parameter estimates in model estimation (Huber et al ,1982). Also using non-dominant choice tasks helps to avoid having another extra choice tasks thereby reducing the work load and putting less constraint on the available time for the survey. The disadvantage of using non-dominant choices is that respondents who did not take the survey serious cannot be easily removed. However, the model fit can give an indication whether results are better than random selection.

Note that it is easy to check for dominance in these choice tasks because they only contain cost and time attributes. For choice tasks with more than two attributes or where it is not clear whether it contains dominant tasks or not, it is not easy to manually check for dominance. In these cases, it is recommended to use automatic methods for detecting dominance and accounting for it in model estimation. See for example the procedure described in (Bliemer et al,2017).

4.3.6. Cost, time levels and distance classes

As with the pilot design, three distance classes, short, medium, and long are used. 9292.nl was used to get actual cost for trip lengths and corresponding travel times. The 40% discount ticket which is the most common price was used. Prices are between 2 and 5 euros for short, 6 and 9 euros for medium, and 9 to 12 euros for long. Travel times are reasonably close to expected travel times for those distances. The time and cost levels used for the pilot were slightly modified to fit in with the new design. Below are the cost and time levels used for final design.

Table 4-4: In-vehicle travel time level used for design (In minutes)

Distance Class	Pilot	Main design
Short	6, 12 ,18, 24	**10,20,30**
Medium	30 ,40 ,50 ,60	**35,50,65**
Long	70,90,110,130	**80,100,120**

Table 4-5: Travel cost levels used for designs(In Euros)

Distance	pilot	Main design
Short	1.5, 3, 4.5, 6	**3, 4.5, 6**
Medium	4,6,8,10	**6,8,10**
Long	7.5,10,12.5,15	**8,12,16**

Note that the distance classes (short, medium and long) serve two purposes. First to cover different ranges of VOTTS and secondly, to serve as blocks of design for the context with and without activity. The description of the context and the motivation for using different distance class for each context are described in the next sections.

4.3.7. Context

There are two contexts defined by the ability to perform one's preferred activity during the journey. To avoid any bias relating to the train environment, the context is linked to the availability of the equipment needed for that activity. So, respondents are told to imagine that they are able to perform their preferred activity because they have the required equipment and material for that or they are not able to perform their preferred activity because they forgot the equipment or material needed for that activity. Also, this ensures that respondent make their choices assuming the normal conditions of the train when they make their trip. This means that VOTTS with activity should be close to the current VOTTS since people already perform these activities during their trips. It is possible to make this comparison after estimating VOTTS.

The VOTTS in the context without activity should change if activities play a role in how travellers value their travel time. If the activities do not have any significant impact on their VOTTS then it is expected that respondents will ignore the context and make the choices they would otherwise have made when the ability to perform activities was involved.

4.3.8. Showing two different distance classes to respondents

Ideally, it would have been better to keep exactly the same choice task on both context (with and without activity) to measure the real change in VOTTS as described in the original self-engagement experiment. However, this might make respondent feel the need to change choice or just fill in the previous choice without considering the context. To avoid this, distance class is changed when context changes so respondents have to revaluate their choices instead of just changing the previous choice to favour the research.

4.3.9. Balancing design with context and distance classes

Since we have two contexts (with and without activity) and three distance classes (short, medium, long), the SP design needs to be balanced to reduce bias. This resulted in a total of six different variations of SP experiments (three with activity and three without activity). Respondents were randomly assigned to the experiments to balance distance and context(see appendix for actual distribution of respondents by distance and context).

Table 4-6: Variations of SP survey

SP experiment	Description
1. Short-with activity	A short trip(10-30mins) where respondent is able to perform preferred activity because he has the required equipment for that activity.
2. Short-with no activity	A short trip where respondent is not able to perform preferred activity because he forgot the required equipment for that activity.
3. Medium-with activity	A medium trip (35-65mins) where respondent is able to perform preferred activity because he has the required equipment for that activity.
4. Medium-with no activity	A medium trip where respondent is not able to perform preferred activity because he forgot the required equipment for that activity.
5. Long-with activity	A long trip (80-120mins) where respondent is able to perform preferred activity because he has the required equipment for that activity.
6. Long-with no activity	A long trip where respondent is not able to perform preferred activity because he forgot the required equipment for that activity.

To remove order effect: We randomize which SP is shown first to the respondent (with or without activity). This removes the bias that change in VOTTS was because the context with activity was shown first or shown last to respondents. So, some respondents get SP with activity first and others get SP without activity first.

For the modelling, all SP experiments for ***all three distances with activity are combined for every respondent***. Similarly, all SP experiments for ***all three distances without activity are combined for every respondent***. That is 6 choices with activity and 6 choices without activity. The uniqueness of this survey is that the ***same respondents*** who did the SP with activity also did the SP without activity. In theory, even though the first series of choices they got differ from the second series of choices in terms of distance class, the VOTTS calculated from both choices should not change significantly because the respondents do not change. The hypothesis is stated below:

Hypothesis

Since the ***SP with activity and SP without activity has exactly the same respondents*** *their average VOTTS should be the same (i.e. no significant difference in VOTTS)* ***unless the ability to perform their activity has an effect on their VOTTS.***

Testing hypothesis

The hypothesis above is a strong hypothesis given that the distance class changes when the context changes. Also people are randomly assigned to experiments (short, medium, long). So, a change in VOTTS could be because of which SP the respondents saw first and which one second and not necessarily because of the ability to perform the activity.

The hypothesis above is specifically tested (see section 5.3) during the modelling stage by comparing the VOTTS calculated from the first 6 series of choices (regardless of distance or context) of respondents with their second 6 series of choices (also regardless of distance or context). This comparison is possible because the order of SP with and without activity is randomised and also distance classes are randomly assigned. Ideally, since we only change the context and not the respondents, we expect that their ***VOTTS should not be significantly different just because they completed exactly same SP twice!***

4.3.10. Design and priors

The Ngene software (Choice Metrics,2012) was used to make the designs. The technique of d-efficient designs (Bliemer and Rose, 2010) using priors was used in order to minimise standard errors. The priors used were from the pilot survey. Since the model fit of the pilot were poor, we used the priors from the model with the best model fit for with and without activity. Also in order to avoid any bias in terms of VOTTS for the context with or without activity, the average VOTTS for both context was used. This ensures that the ***SP of with activity is exactly the same with the SP without activity***. So only the context changes.

Table 4-7: Priors used for Design

Priors	With activity	Without activity	average
Time	-0.0864	-0.105	-0.0957
Cost	-0.484	-0.380	-0.432
VOT(euros/hr)	10.71	16.58	**13.65 euros/hr**
Rho-square	0.161	0.139	

4.3.11. Example of SP survey received by a respondent

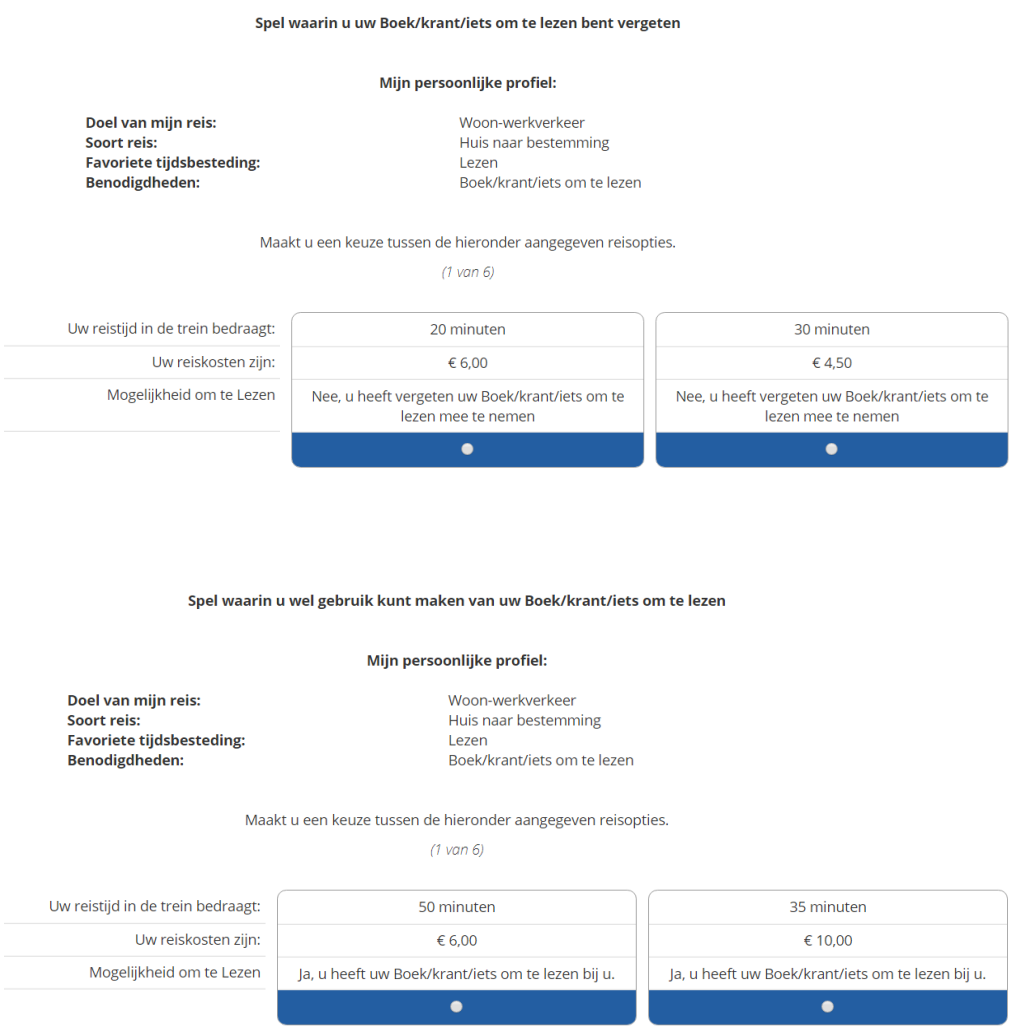

Figure 4-1: Example of SP with and without activity(Dutch)

English Translation (Example Survey)

Your personal profile

Trip purpose: Commute

Type: Home to destination

Preferred activity: reading

Required Material: book/reading material

Table 4-8: English Translation of example SP survey

SP without Activity1

	Trip A	Trip B
Time	20	30
Cost	6	4.5
ability to read	No You forgot your reading materials	No You forgot your reading materials

SP with Activity1

	Trip A	Trip B
Time	50	35
Cost	6	10
ability to read	Yes You have your reading materials	Yes You have your reading materials

4.4. Analysis Technique

4.4.1. Discrete Choice Models

Discrete choice is used in this thesis to model choice behaviour of respondents. The models assume that when decision makers are faced with different choice alternatives, they choose the one which maximises their utility. This is the so-called utility maximisation theory. The mathematical description of the theory is given below (Train,2003):

A decision maker n faces a choice between alternatives $1,2,\dots J$ each with a known utility U_{nj}. He chooses alternative i if and only if $U_{ni} > U_{nj}\ \forall\ j \neq i$. This utility U_{nj} is not known by the researcher but rather a set of attributes x_{nj} of each alternative is observed. Consequently, the utility U_{nj} is made up of two components, an observed component $V_{nj} = V(x_{nj})$ and an unobserved part ε_{nj}.

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad (3)$$

Since the ε_{nj} is unknown, the researcher assumes that it is random and follows a particular distribution. The choice of alternative now changes from a deterministic to a probabilistic one. The probability that the decision maker n will choose alternative i is defined as the probability that $U_{ni} > U_{nj}\ \forall\ j \neq i$. In order to calculate this probability, the distribution of the unobserved component ε_{nj} must be assumed by the researcher. The assumption made by the researcher for the distribution leads to different model specifications. The two most common model specifications are described below.

4.4.2. Basic Logit Model

This is the simplest and most popular model specification. In this model, it is assumed that the unobserved ε_{nj} is distributed independently, identically extreme value (i.i.d) . This means that the unobserved ε_{nj} is independent of $\varepsilon_{ni}\ \forall\ j \neq i$. i.e. all unobserved characteristics of one alternative is uncorrelated to the unobserved characteristics of another alternative. Of course, this is a strong assumption but the advantage of using this specification is that the probability that an alternative $P_{ni}\ i$ will be chosen by respondent n i.e. that $U_{ni} > U_{nj}\ \forall\ j \neq i$ can be expressed in a simple closed-form formula without the need to numerical evaluate an integral. The formula is given below:

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}} \quad (4)$$

Where $V_{nj} = \beta' x_{nj}$, x_{nj} is a vector of the observed variables of alternative j and β' is a vector of unknown parameters to be estimated.

This simple model can also be extended to include social-economic variables relating to the respondent e.g Age, gender, income etc. This enables the researcher to account for possible interaction between attributes of alternatives and the characteristics of the respondents.

In this SP survey, respondents only have to choose between two alternatives. Therefore, the model described above reduces to a ***binary logit model***. From now onwards we refer to this simple model as a binary logit model.

Limitations of Binary Logit model

The model although simple and easy to understand has some notable limitations. The first limitation is that it cannot capture random variations in the taste parameters. The model assumes that the taste parameters are constant for all respondents but in reality, these taste parameters can be randomly distributed with a mean and standard deviation allowing each respondent to have his own unique taste parameters or for different taste parameters for different segments of respondents.

Finally, binary logit models assume that the unobserved factors are uncorrelated over time in repeated choices (Train ,2003). However, in case of panel data where respondents make repeated choices in one experiment, the unobserved factors could be correlated. This is because a respondent taste for certain attributes can echo through all their choices. So, a person who dislikes high travel cost will have the same dislike for all high travel costs in the choices they make. For example, if a respondent makes 6 choices, a binary logit model assumes all 6 choices are independent while in reality they could be correlated. The consequence is that the binary logit will tend to overestimate the precision of parameters by giving high t-values (low standard errors). This can lead to bias in results.

4.4.3. Mixed Logit

To overcome the above discussed limitations of binary logit, mixed logit models have been developed. These models can be used to account for randomness in taste parameters and can also take into account the panel structure of data. The mathematical specification of the model is described below(Train,2003):

The utility of a respondent n from alternative j is specified as:

$$U_{nj} = \beta_n' x_{nj} + \varepsilon_{nj} \quad (5)$$

Where x_{nj} are observed variables that relate to the attributes of the alternatives and the decision maker, β_n' is the taste parameter of respondent n and ε_{nj} is a random term that is iid extreme value. The main difference between this specification and the binary logit is that β is not fixed but varies over decision makers with density $f(\beta)$. This density function has mean and a standard deviation. The probabilities of a ML specification are integrals of the logit model over a density of parameters.

$$P_{ni} = \int L_{ni}(\beta)\, f(\beta) \mathrm{d}\beta \quad (6)$$

Where L_{ni} is the logit probability evaluated at β.

$$L_{ni} = \frac{e^{V_{nj}(\beta)}}{\sum_j e^{V_{nj}(\beta)}} \quad (7)$$

$$P_{ni} = \int \left(\frac{e^{\beta_n' x_{ni}}}{\sum_j e^{\beta_n' x_{nj}}} \right) f(\beta) \mathrm{d}\beta \quad (8)$$

4.5. Model Specification

4.5.1. Binary Logit model

The Discrete choice models discussed before will be used to estimate the VOTTS for each scenario. The binary logit model is selected because of its simplicity and also because it is commonly used for value of time estimations, so results are easily comparable with other studies.

The hypothesis for the SP experiment is that if the activities performed during trip do not have an impact on traveller's valuation of time then his VOTTS for performing and not performing activities should remain the same (i.e. his choice on both scenario will be the same). Since the survey has cost and time attributes, the VOTTS can be calculated. The utility function for the model is shown below:

$$V(Trip1 - without\ preferred\ activity) = \beta_{Time1} * TT + \beta_{cost1} * TC \quad (9a)$$

$$V(Trip2 - with\ preferred\ activity) = \beta_{Time2} * TT + \beta_{cost2} * TC \quad (9b)$$

$$TT = in - vehicle\ travel\ time$$

$$TC = travel\ cost$$

It is expected that people will make slightly different choices in the scenarios of performing activity compared to when they are not able to in all choices. The cost and time parameters will be different and hence a different VOTTS will be calculated. The difference between these two VOTTS is the hidden value of the activity in euros/hour.

$$VOTTS1 = \frac{\beta_{Time1}}{\beta_{cost1}} * 60 \quad (9c)$$

$$VOTTS2 = \frac{\beta_{Time2}}{\beta_{cost2}} * 60 \quad (9d)$$

$$V_A = VOTTS_1 - VOTTS_2 \quad (9e)$$

4.5.2. Equivalent model in VOT space

The model given above captures the VOTTS with activity and the change in value of time but it does not tell us whether the VOTTS and the change in value of time due to context is statistically significant or not. To overcome this problem, the model is respecified in VOT space into one combined model as follows:

$$V_i = \mu(\beta_c * TC_i + \beta_c * VOT * TT_i + CON_{ACT} * \beta_c * \Delta VOT * TT_i) \quad (10)$$

Where $CON_{ACT} = \begin{cases} 0 & if\ SP\ with\ Activity \\ 1 & if\ SP\ without\ Activity \end{cases}$

$$\mu = \exp(\gamma * CON_{ACT})$$

In this model, $\Delta VOT = V_A$

The way the model is specified now is mathematically equivalent to the previous specification with the added advantage that we can immediately tell if the VOTTS with activity is significant and also if the change in VOTTS due to the inability to perform activity is significant.

μ is a scale parameter used to capture any difference in the scale of errors between both contexts . This is used as an indication of balanced SP in terms of context. Ideally the scale parameter should be insignificant equal to 1 or $\gamma = 0$. However, we estimate a scale parameter for context because respondents are randomly assigned SP with a change in distance class (cost and time) when context changes. So, there is a difference in scale errors between the two contexts which the parameter can capture.

4.5.3. Binary Logit in VOT space with interaction

$$V_i = \mu\left(\beta_c * TC_i + \beta_c * VOT_{ref} * A * TT_i + CON_{ACT} * \beta_c * \Delta VOT_{ref} * B * TT_i\right) \quad (11)$$

Where $CON_{ACT} = \begin{cases} 0 & if\ SP\ with\ Activity \\ 1 & if\ SP\ without\ Activity \end{cases}$

$$\mu = \exp(\gamma * CON_{ACT})$$

$$A = \left(1 + \sum_i fac1_i * DUM\_VAR_i\right)$$

$$B = \left(1 + \sum_i fac2_i * DUM\_VAR_i\right)$$

The model above is essentially the same as the binary logit model of equation (10). The only difference is that the reference VOTTS and the reference value of activity (ΔVOT) are multiplied by ($1 + fac_i * DUM\_VAR_i$)

Where DUM_VAR_i is the dummy variable created for the interaction variable.

$fac1_i$ is the factor coefficient representing an increase or decrease in the VOTTS due to the interaction variable DUM_VAR_i. A factor coefficient of 0.1 implies that the VOTTS is increased by 10% while a factor coefficient of -0.1 implies a decrease of 10% on the VOTTS.

A different coefficient is used for the interaction of the ΔVOT with the variable DUM_VAR_i. This ensures that the VOTTS and the value of the activity can be influenced in a different way by the same variable.

$fac2_i$ is the factor coefficient representing an increase or decrease in the value of the activity due to the interaction variable DUM_VAR_i.

Note that this specification and dummy coding for interaction variable was chosen because of its ease of interpretation and also because it was also used for the national value of time calculations for the Netherlands (Significance, 2013). This facilitates easy interpretation of results and also easy comparison with national VOTTS results for interaction variables. Also, the national VOTTS were also estimated in VOT space just like in this thesis which is another advantage in terms of comparison.

4.5.4. Panel Mixed Logit with interaction

Given the limitations of binary logit model, a panel mixed logit model with interaction will also be estimated to check for possible heterogeneity in VOTTS and value of activity. As discussed before, Mixed logit models assume that the parameter of interest is distributed according to a known statistical distribution e.g. normal, lognormal, triangular, uniform etc. However, the choice of which distribution to use is not straightforward because it usually not known beforehand. The aforementioned distributions each have their advantages and disadvantages so the choice depends on the parameter of interest, model fit, and interpretation of results (Hess et al,2005). In our case (equation 11), the VOTTS is expected to be positive since the cost parameter is negative. So, people should be willing to pay to reduce travel time and not pay to increase it. Even when travellers are able to perform activities, it expected that the priority is still to arrive at destination as soon as possible. The implication of using the above distributions is discussed below:

If VOTTS is normally distributed with a mean and standard deviation, then it is possible that a significant proportion of respondent will have a negative VOTTS if the standard deviation is large. This is not desirable.

A uniform distribution is rarely used in practice because it assigns equal probability to all values in the domain (Hess et al,2005). This is not desirable because it means that a very high or very low VOTTS will both have equal probability. This is also undesirable.

A triangular distribution is more appealing than a uniform distribution because it allows values to have different probabilities like a normal distribution. However, the linear segments restrict its use (Hess et al,2005).

For all these three distributions above, it is possible to have a significant proportion of respondents having negative VOTTS making it difficult to interpret results.

A lognormal distribution allows for estimation of parameters in the positive domain however, it is characterised by an unbounded upper tail (Hensher and Greene, 2003) which could lead to unrealistically high VOTTS. In our case, this could affect both the VOTTS with activity and the change in VOTTS since we measure differences in VOTTS.

Given the limitations of the above distributions, a solution is to constrain the spread or standard deviation of the distribution to a certain proportion of the mean (Hensher and Greene,2003). This can be used on any distribution to reduce the share of people with negative VOTTS. During the model estimation, different distributions will be tried in order to select the best one in terms of model fit and also interpretation of results.

The number of draws are gradually increased starting from as low as 25 Halton draws to 50 and doubled until stability of parameter is achieved (Hensher and Greene ,2003).

CHAPTER 5: DATA ANALYSIS AND MODEL ESTIMATION

5.1. Introduction

As discussed in the previous chapter (section 4.1), the survey conducted was split into two parts. The first part of the survey consisted of questions relating to the most frequent trip made by the respondent when using the train.

Some of the questions asked during the first part of the survey are:

- Trip characteristics e.g. duration and frequency
- The main activities performed during the trip
- Equipment needed to perform the activity
- The comfort needed to perform the activity e.g. quiet environment, seat, Wi-Fi etc.
- Worthwhileness valuation of the trip with and without the main activity on a 1-10 scale
- Assessment of the train as the ideal place to perform the activity

After this, respondents were presented the SP survey depending on the activity selected and the equipment chosen.

Since there were so many questions asked concerning various activities, only the most relevant results relating to the three activities of interest in this thesis (i.e. reading, working/studying and listening to music) are presented here in this chapter. This makes it easier to relate descriptive results to the results of the SP survey.

5.2. Descriptive analysis on activities

The results of some selected questions asked during the survey are presented here. The focus is on the activities reading, working and listening to music. Only questions relating to the activity and the ability to perform the activity on the train is presented. This is to enable us relate quantitative results from the SP to this descriptive analysis.

5.2.1. Activities engaged in during travel

A total of 1558 respondents participated in the survey. About 35% of respondents are commuters and 47% are leisure trip makers. This is close to the actual distribution by trip purpose of NS travellers which is 34% and 41% for commute and leisure trips respectively(NS,2014).

From the table 5-1 below, it is clear that the activities reading and working are more popular on the outbound trip compared to the inbound trip (This means that it was a good choice to separate the inbound and outbound activity during the survey). About 39% of commuters read as main activity on their way to work compared to 28% on their way back home. This is also true for commuters who work on the trip which drops from 19% to 14%.

This is not the case for the activity listening to music which is slightly more preferred by commuters on the inbound trip (8%) compared to the outbound trip (6%) .

For leisure travellers, the activity working is not popular (only 4% outbound and 3% inbound) which indicates that people would rather engage in other activities instead of work. Reading is even more popular among leisure travellers as main activity with about 50% choosing it as main activity.

Table 5-1: Distribution of main activity based on this survey

Activity	Commute		Leisure	
	Outbound	Inbound	Outbound	Inbound
Reading	39%	28%	50%	41%
Working/Studying	19%	14%	4%	3%
Listening to music	6%	8%	6%	7%
Total	64%	50%	60%	51%

In a similar survey conducted by NS on activities performed during train trips(NS,2014) , about 49% of commuters reported reading during the outbound trip and 35% on the inbound trip compared to this survey(39% and 28% respectively). In the same study ,10% of commuters reported working during the outbound trip and about 8% during the inbound trip compared to this survey (19% and 14% respectively). Although the results in this survey slightly differs from those of NS, the findings relating to difference of outbound and inbound trip is consistent with that of (NS,2014). It could be that reading and working require more effort and concentration so commuters opt for less demanding activities when they are going back home resulting in lower percentage for working and reading on inbound trips.

Note that the survey conducted by NS(NS,2014) did not ask people for a main activity but just a list of activities they carry out on their trip. So, a traveller can choose more than one activity which is usually the case. This means that the percentage of people reading, working or listening to music found in the previous NS survey cannot not be directly compared to this survey.

5.2.2. Equipment and comfort required for selected activities

Respondents were asked which equipment they need for the chosen main activity. This enabled the SP to be customised for each respondent depending on the equipment required for the activity. Additionally, respondents were also asked for the comfort level in the train they require to perform the activities. Note that since we are interested in the activity, the presented results are for all trip purposes.

Table 5-2: The equipment and comfort needed for selected activities

		Reading	Working	Listening to music
Share of all trip purposes	Outbound	42%	14%	7%
	Inbound	33%	10%	8%
Equipment	telephone/ipad	38%	66%	79%
	laptop	5%	76%	2%
	headphones	5%	22%	71%
	book/paper	88%	33%	8%
	e-reader	7%	0%	0%
Comfort required	seat	78%	72%	72%
	enough leg space	30%	37%	26%
	table	10%	53%	4%
	electrical socket	8%	43%	16%
	quietness	54%	59%	36%
	wifi	18%	56%	22%

Table 5-3: Other relevant questions concerning selected activities

Questions relating to activity				
		Reading	Working	Listening to music
Time spent on activity (Approximate)	A quarter of trip	3%	0%	3%
	Half of the trip	26%	16%	15%
	Three-quarter of trip	52%	61%	28%
	Full trip	19%	23%	54%
	% of trip time for activity	72%	77%	83%
Ideal place for activity	In the train	24%	6%	31%
	Home	46%	34%	27%
	At the office	**1%**	**37%**	**0%**
	Somewhere else	2%	4%	4%
	I do not have a preference for a location	27%	19%	38%
Time needed for activity	Much more time needed in the train	4%	7%	4%
	More time needed on the train	43%	51%	8%
	Same time in the train	45%	31%	84%
	Less time needed in the train	6%	8%	4%
	Much less time needed in the train	2%	2%	0%
Productivity	% productive	91%	98%	47%
Pleasantness	% pleasant	97%	66%	94%

Reading

This is a popular activity across all trip purposes especially on the outbound trip where about 42% of respondents are reading as main activity. The equipment required for this activity is normally a book/newspaper/reading material (88% of people reading need these). Interestingly there is a substantial share of people who need a telephone/ipad for reading (38%) . This could be explained by the ability to read a newspaper or even a book in pdf format using these devices. Also, the e-reader was quite popular even though it wasn't on the list of equipment. So, in total around 45% of people who read use non-paper based material for it. This is consistent with the findings of Lyons et al 2016 who reported a shift from paper based materials to digital because of the increased use of ICT devices.

In terms of comfort, the most important requirement is the ability to sit during the journey (78%) followed by the need for a quiet environment(54%). Also, around 30% of those who read need a seat with enough legroom. This could be because they want to be able to relax and feel comfortable while reading.

People who read usually do this for about 72% of total trip time with about 50% of people reading for approximately three-quarter of the trip. The remaining part of the trip is probably being used to set-up for the activity or perform another activity.

Around 25% of travellers consider the train as their favourite place for reading while about 27% have no preference. This indicates that for about 50% of readers, the train is convenient. This is also supported by the fact that 53% of people reading need same time or less to read on the train compared to their ideal place of reading.

Finally, for most travellers, reading is considered as both productive (91%) and pleasant (97%), though the percentage for pleasant is a bit higher than for productive, indicating that reading is regarded as (a bit) more pleasant than productive. These findings are consistent with Van Hagen et al. (2016).

Working

Working during the trip is not as popular as reading with only about 14% of respondents working as main activity in the outbound trip and 10% in the inbound trip. The most popular equipment needed for working is a laptop (about 76% of respondents). This is in clear contrast to reading where only 5% need a laptop. This indicates that the activity reading and working are clearly different in terms of requirement for a laptop. However, around 66% of people who work also need a telephone/iPad for working. This is not a surprise as most phones/iPads can be used for various work-related activities like sending emails, typing a document etc. They also have the added advantage of being much lighter and portable than laptops.

With regards to the comfort needed for working, most people need to be able to sit (72%) ,59% need a quiet environment, 56% need wifi , 53% need a table, 43% need an electric socket, while around 37% need enough legroom. From the requirements above, it is clear that people need to feel very comfortable to work (much like in an office setting). Given these requirements, it is possible that the low percentage (compared to reading) of people working during their trip could be related to the current comfort level in the train.

People who work usually do this for about 77% of total trip time with about 61% of people working for approximately three-quarter of the trip. Only 6% of travellers consider the train as their favourite place for working (in clear contrast to reading) while about 19% have no preference. This indicates that only 25% of people working consider the train as convenient. Also, only 41% of people working need same time or less to work on the train compared to their ideal place. This could indicate that the train is not very suitable for working for most people.

Finally, for most travellers, working is considered as productive (98%) but less pleasant compared to reading (66%). These findings are also consistent with Van Hagen et al. (2016) who find that working during the trip is mostly considered as productive rather than pleasant.

Listening to music

Listening to music is not a popular main activity during travel with only about 7% of respondents choosing it as main activity for outbound and 8% for inbound. Note, that the small number of people listening to music does not mean music is not enjoyable but it could be that it is often combined with other activities e.g. working or reading. Van Hagen et al(2016) found that about 20% of train travellers(especially those on education trips) listen to music during the trip. This means that a lot of people listen to music but not as main activity. As expected the equipment needed for listening to music is a phone/iPad(79%) and headphones(71%).

In terms of comfort, people who listen to music still need to be able to seat (72%) , a quiet environment(36%), 26% need enough legroom and 22% need wifi. The need for quiet environment, and legroom could be related to their ability to enjoy the trip as a regular traveller and not necessarily related to the activity.

People who listen to music usually do this for about 83% of total trip time with more than half of them listening to music during the whole trip. The higher percentage could be linked to the fact that listening to music requires less set-up time compared to working and reading.

Around 31% of travellers consider the train as their favourite place for listening to music while about 38% have no preference. This indicates that 69% of people listening to music consider the train as convenient. Also, 88% of people listening to music need same time or less on the train compared to their ideal place. It can be concluded that the train is quite suited for listening to music.

Finally, for most travellers, listening to music is considered as pleasant (94%) but not really productive (47%). These findings are also consistent with Van Hagen et al. (2016) who find that listening to music during the trip is mostly considered as pleasant rather than productive.

Some comments

- ***Activities and equipment overlap***

As can be seen, the phone/ iPad can be used for reading, (33%) , working(66%) and listening to music(79%). Although the phone/iPad can be used for these three activities, the value of the activities and also the impact on the VOTTS of the traveller could differ. This clearly supports the decision to focus on activities instead of ICT devices.

- ***Reading for work or reading for leisure***

Although in the survey, there was no distinction between reading for leisure and reading for work, there is a strong indication that the respondents clearly understood the difference. The most obvious one is that ***only 1% of people reading consider that the office is the ideal place for the activity while 37% of people working consider the office the ideal place.*** This shows that both activities are clearly different and that people do not want to read in the office. There are other subtle indications which shows people are reading for leisure instead of work. For instance, only 5% of people reading need a laptop compared to 76% of people working. More people prefer to read on the train (24%) compared to working (6%). So, even though it is impossible to tell, the evidence show that it is more likely that those reading are doing it for leisure rather than for work purposes.

5.3. Exploring relationship between activity and socio-demographic variables

It is of interest to know which socio-demographic variables influence the type of activity a traveller engages in. Previous research has shown that for some activities ,variables like age, gender, income etc play a role (Keseru and Macharis,2017). For example, it has been reported that older people prefer to engage in activities which do not require ICT devices such as reading a book or newspaper (Berliner et al., 2015; Frei et al., 2015) while younger people (below 34) prefer to use such devices for activities such as listening to music. Some research has also found that women are more likely to read than men (Frei et al,2015). Based on this, we explore relationship between socio-demographic variable first by looking at the proportion of people within such categories. Then a chi-square test is performed to check whether there is a significant relationship between such variables and the activities reading, working and listening to music. The results based on all trip purposes are presented below:

5.3.1. Activity and Age

There is a steady increase in the proportion of people who read as the age increases. In general, people above 35 years tend to read more than the younger people. This is consistent with other research (Berliner et al., 2015; Frei et al., 2015). However, those above 75 years do not read much this is probably related to the physical and mental requirement rather a dislike for the activity. In clear contrast, the proportion of people listening to music declines as the age increases indicating that young people are more likely to listen to music. Specifically, those below 35 years make up about 50% of those who listen to music. This is consistent with previous research (Berliner et al., 2015; Frei et al., 2015). Also, the research by NS (NS,2014) found that 76% of those listening to music are below 35 years.

For the activity working, the age groups above 65 clearly differs from the rest. This is probably related to the retirement age for working which is around 65 years old and also the physical and mental requirement for the activity. This is also consistent with NS data

(NS,2014). On the other hand, age group between 25 and 54 years are more likely to work compared to others.

Table 5-4: Age distribution per activity type

Activity and Age								
			Age					
			18-24	25-34	35-44	45-54	55-64	65-74	75+
Activity	Reading	N	26	69	94	99	118	125	52
		%	4.5%	11.8%	16.1%	17.0%	20.2%	21.4%	8.9%
	Music	N	50	36	25	21	11	4	2
		%	33.6%	24.2%	16.8%	14.1%	7.4%	2.7%	1.3%
	Working	Count	39	44	47	47	36	3	3
		%	17.8%	20.1%	21.5%	21.5%	16.4%	1.4%	1.4%

5.3.2. Activity and Gender

The proportion of females reading is slightly higher than that of men (consistent with Frei et al 2016). However, it appears that more women listen to music compared to men (in contrast with (Keseru et al 2015) who reported more men listening to music although their research is based on car drivers and not on train users. Finally, there is a significant proportion of men working (63%) compared to women (37%). This has not been reported in other research. There could be some possible explanation for this but further research is needed to verify this.

Table 5-5: Gender distribution by activity type

Activity and Gender				
			Gender	
			Male	Female
Activity	Reading	N	314	331
		%	48.7%	51.3%
	Music	N	73	86
		%	45.9%	54.1%
	Working	N	156	93
		%	62.7%	37.3%

5.3.3. Activity and Income

The average income used was 37000 euros per year gross (27000 euros net) which is close to the average income in the Netherlands. From the table 5-6 below, it clear that those listening to music probably have a lower income than those reading or working with more than 50% of those listening to music earning below the average income. The difference income could be also related to the age since younger people are usually still students or recent graduates with smaller years of experience. The activities reading and working are

quite popular with those with 1-2 times the average income. About 33% of those reading and 35% of those working belong to this income category.

Table 5-6: Income level distribution by activity type

Activity and Income						
			Income2			
			Less than average	About average	1-2 times the average	more than twice the average
Activity	Reading	N	139	165	191	80
		%	24.2%	28.7%	33.2%	13.9%
	Music	N	68	37	23	5
		%	51.1%	27.8%	17.3%	3.8%
	Working	N	54	50	79	42
		%	24.0%	22.2%	35.1%	18.7%

5.3.4. Activity and Education level

From the table below, those working are most likely to have an education level 8 (university) or above. In fact, the proportion of people working increases with the education level. For reading, only about 14% have education level below 5. Above this level, there is not so much difference between the proportion of people reading. This indicates that reading is more related to ability and likeness for the activity rather than education level. The activity listening to music is most popular with those of education level 5-7. In general, around 78% of those listening to music have an education level lower than level 8(university).

Table 5-7: Education level distribution by activity type

Activity and Education					
			Education		
			Education level 1-4	Education level 5-7	Education level 8 and above
Activity	Reading	N	85	263	248
		%	14.3%	44.1%	41.6%
	Music	N	36	78	33
		%	24.5%	53.1%	22.4%
	Working	Count	11	87	131
		%	4.8%	38.0%	57.2%

5.4. Activity and other variables

Due to the nature of the survey, it is expected that the type of ticket possessed by the respondent will have an influence on the VOTTS and hence on the value of the activity. Especially those who don't pay at all or are partially reimbursed by their employer. Also, the trip duration is expected to affect VOTTS and value of activities. To enable us relate VOTTS to these variables, we examine these two variables in relation to the type of activity.

5.4.1. Activity and Ticket

From the table below, most the people reading (67%) pay for the travel ticket themselves. This is not the case for those working which has only 30% of people paying for themselves. This could indicate that those who read do it voluntarily while those who work might be doing so as a form of compensation for their employers. However, there is no way to verify this, as people were not asked specifically why they work.

Table 5-8: Ticket payment distribution by activity type

Activity and Ticket						
			Ticket Payment			
			Pay Myself	Employer pays half	Employer pays full	Other
Activity	Reading	N	438	71	111	33
		%	67.1%	10.9%	17.0%	5.1%
	Music	N	73	20	29	37
		%	45.9%	12.6%	18.2%	23.3%
	Working	N	74	46	91	38
		%	29.7%	18.5%	36.5%	15.3%

5.4.2. Activity and Trip duration

Previous research showed that 15 minutes is a reasonable threshold for activities on trains (Keseru and Macharis,2017, Lyons et al., 2007) while people mostly work during commute if the journey is longer than 30 minutes (Frei et al., 2015).

From the table below, there appears to be no clear pattern between activity type and trip duration. However, all three activities have the highest proportion for trip duration between 31-60mins. This could be an ideal trip duration to engage in any activity but not necessarily a particular activity.

Table 5-9: Trip duration distribution by activity type

Activity and Trip duration							
			Trip duration				
			0-30mins	31-60mins	61-90mins	91-120mins	more than 120mins
Activity	Reading	N	136	205	112	103	97
		%	20.8%	31.4%	17.2%	15.8%	14.9%
	Music	N	42	48	26	22	21
		%	26.4%	30.2%	16.4%	13.8%	13.2%
	Working	N	39	75	51	44	40
		%	15.7%	30.1%	20.5%	17.7%	16.1%

5.5. Chi-square test of relationship between variables and activity

Although, the various proportions of respondents who read, work or listen to music and belong to the categorical socio-demographic variables are known. It is impossible to tell if there exist a significant relationship between the activity and the variable. In order to test for this relationship, a chi-square test of association is performed. The null hypothesis for the test is that two categorical variables are independent i.e. no significant relationship exist between the two variables.

For each activity reading, working and listening to music, two categorical variables are created. Each respondent belongs to the categorical variable of activity if they engage in the activity. The categories for the socio-demographic variables are the same as in the previous section 5.3 and 5.4. The results for the chi-square test for all variables and activity pair are presented in the next section. Note that a high bivariate residual (low p-value) indicates a strong relationship between the two variables. A 5% significance level is used for rejecting or accepting the null hypothesis.

5.5.1. Reading

For the activity reading, ticket type and age have the highest relationship. This indicates that these two variables are important for those who read. This is expected since we found that the proportion of those who read during their trip increases with age (except for 75+). Also, among those who were reading most of them pay for the ticket themselves. The variable gender is still significant at 5% level which shows that it could play a role for the activity reading. This could be related to the fact that there were slightly more females than males reading. Income, Education and trip duration were not significant at 5% level indicating that there is no significant relationship between these variables and the activity reading. It could be that reading is related to the ability to read and the likeness for the activity rather than income.

Table 5-10: Chi-square test of association for activity Reading

READING		
Indicators	Chi-square(BVR)	P value
Ticket	26.07	0.00
Age	24.66	0.00
Gender	4.26	0.04
Income	3.45	0.06
Education	0.71	0.40
Trip duration	0.31	0.57

5.5.2. Working

Ticket type, gender and education level and age have a very strong relationship with the activity working. For those working we found that most of them do not pay fully for their ticket but rather the employer pays some or all. The significant relationship of gender is clearly related to the high proportion of males working compared to females. As stated before, the reason for this is not yet understood and should be researched further. The relationship of education level reflects the fact that those with lower education level are probably not employed yet and hence don't work during their trip while those with a high education level are more likely to have a job and thus can work during the trip. Finally, the significant relationship of age and working is probably related to the education level and also the physical and mental requirement for the activity. People working were mostly between 25 and 54 years old. Income and trip duration were not significant. This could mean that people will work during their trip regardless of income as long as they have a job.

Table 5-11: Chi-square test of association for activity working

WORKING		
Indicators	Chi-square(BVR)	P value
Ticket	23.05	0.00
Gender	16.87	0.00
Education	14.37	0.00
Age	8.64	0.00
Income	3.11	0.08
Trip duration	1.11	0.29

5.5.3. Listening to music

Income, age and education level have the most significant relationship with the activity listening to music. This is expected because more than half of those listening to music has less than the average income. The age relationship is also clear since about half of those listening to music are below 35 years old. Also, more than 75% of those listening to music

have education level lower than university. Ticket type and gender still has a significant relationship with listening to music although not as strong as the Income age and education level.

Table 5-12: Chi-Square test of variation for activity listening to music

MUSIC		
Indicators	Chi-square(BVR)	P value
Income	15.05	0.00
Age2	13.90	0.00
Education	12.74	0.00
Ticket	6.93	0.01
Gender	4.45	0.03
Trip duration	0.81	0.37

5.5.4. Summary

There is evidence that activities and socio-demographic variables are related. This is consistent with other findings in literature (Lyons et al,2007, Berliner et al., 2015; Frei et al., 2015, Keseru and Macharis,2017). It is therefore expected that those with different activity type will have different VOTTS and possibly different values of activities. So, this will be checked during the model estimation with interaction variables.

5.6. Worthwhileness of travel time with activity

During the survey respondents were asked to rate (1-10) how worthwhile they consider their travel time if it is spent on doing nothing, doing something else instead of their preferred activity and doing their preferred activity. The average of all respondents is then calculated for these three scenarios. This was used to check whether respondents have a preference for certain activities compared to others. The results are shown below.

Table 5-13: Average worthwhileness rating

All Trip Purposes			
Activity during journey	Reading	Working/studying	Listening to music
Nothing	5.6	4.8	4.9
Something else	6.7	6.6	6.9
Preferred activity	8.2	8.4	7.3
added value of preferred activity	1.5	1.8	0.4

Table 5-14: Average worthwhileness rating for commuters

Commute			
Activity during journey	Reading	Working/studying	Listening to music
Nothing	5.5	4.8	5.5
Something else	6.8	6.7	6.9
Preferred activity	8.2	8.4	7.3
added value of preferred activity	1.4	1.7	0.4

Table 5-15: Average worthwhileness rating for Leisure trips

Leisure			
Activity during journey	Reading	Working/studying	Listening to music
Nothing	5.7	5	5.5
Something else	6.7	6.5	6.9
Preferred activity	8.2	7.9	7.3
added value of preferred activity	1.5	1.4	0.4

As can be seen from the figures above, being able to perform preferred activity while travelling has a significant impact on the worthwhileness of travel time. The biggest effect is from being able to work which decreases from a score of 8.4 to 4.8. This is an indication that for people who work while travelling doing nothing essentially makes the journey worthless. The same can be concluded from those who read. Their rating also falls from 8.2 to 5. 6 another indication of the value of being able to read. For those listening to music, their value also falls from 7.3 to 4.9. Even though we are not able to perform an experiment where people cannot do anything during their trip, these worthwhile rating values give an indication that doing nothing during travel instead of a preferred activity could have a very significant impact on VOTTS.

Overall for these three activities, there is a clear order i.e., ***doing something else is better than doing nothing*** while doing ***your preferred activity is always better than doing something else***. This means that people will always prefer to combine travel with an activity instead of doing nothing. Additionally, people do value their preferred activities more than any other activity. So not being able to perform the activity could have an effect on their VOTTS also (this impact is what is measured in this thesis) .

For those who read and work, it is obvious they prefer these activities as main activity. Those who work gain on average extra 1.8 points from being able to work compared to doing something else while those who read gain extra 1.5 points compared to doing something else. Those who listen to music only gain 0.4 points which is small. This is probably because

they can combine listening to music with other activities hence when music is removed they still have some value for the other activity.

The differences in worthwhileness rating by trip purpose is not that much. Commuters and leisure trip makers rate all three activities quite well. However, there is a noticeable difference between the rating for working during leisure trips compared to commute trips. The rating falls from 8.4 to 7.9. This could indicate that working is more preferred during commute than during leisure trips.

Based on these ratings, it is expected that the value of reading and working will be quite close since both ratings are almost the same. The value of listening to music is expected to be much lower based on the ratings. This will be checked during the model estimation.

5.7. Model results: Impact of activities on the VOTTS

The main research question of this thesis is to check whether the ability to perform certain activities during travel has an impact on the VOTTS of the traveller. The survey was designed such that this impact can be checked per activity type and trip purpose. The impact is measured as the change in VOTTS when the ability to perform the activity is removed. As stated before the impact (difference in VOTTS) is measured for the same people and therefore can be conceptualised as the monetary value of the activity. The results are presented below:

5.7.1. Binary Logit Models

Table 5-16: Binary Logit Models for Commuters

Commute									
	Reading			work			Music		
Observation	2532			1416			660		
Respondents	211			118			55		
Rho-Sq	0.120			0.122			0.109		
	Value	T-ratio	p-value	Value	T-ratio	p-value	Value	T-ratio	p-value
BETA_TC	-0.299	-10.54	0	-0.243	-6.89	0	-0.376	-6.14	0
ΔVOT(€/hr)	4.82	4.63	0	5.31	2.97	0	4.67	2.27	0.02
VOT(€/hr)	11.22	18.7	0	12.72	12.32	0	10.08	10.92	0
gamma	-0.0378	0.28	0.78	0.172	0.84	0.40	-0.279	-1.02	0.31

Table 5-17: Binary Logit Models for Leisure trips

Leisure									
	Reading			work			Music		
Observation	4224			336			672		
Respondents	352			28			56		
Rho-Sq	0.141			0.187			0.123		
	Value	T-ratio	p-value	Value	T-ratio	p-value	Value	T-ratio	p-value
BETA_TC	-0.473	-14.58	0	-0.670	-5.19	0	-0.504	-6.31	0
ΔVOT(€/hr)	3.02	6.52	0	1.17	1.06	0.29	0.33	0.3	0.76
VOT(€/hr)	4.11	12.1	0	6.54	9.58	0	5.95	8.86	0
gamma	-0.190	-1.99	0.05	-0.165	-0.59	0.56	-0.302	-1.27	0.20

5.7.2. Value of Travel time savings with activity (Value of productive/pleasant travel time savings)

The VOTTS for commuters who read, listen to music or work ranges from 10.08 euros/hour to 12.72 euros/hr. This is close to the current official VOTTS for commuter train trips in the Netherlands which is 11.50 euros/hour in 2010 euros (Significance,2013) or 12.76 euros/hr (equivalent 2017 euros) using an average annual inflation rate of 1.5%(inflation.eu). Also, a recent VOTTS time study by (Schakenbos et al,2016) using the panel of NS found an average VOTTS for commute and business trips of 13.21 euros/hour. This is an indication that travellers take into account the ability to perform activities in their VOTTS since this VOTTS with activity is close the current VOTTS.

For leisure trips, the VOTTS for those who read, listen to music or work range from 4.11 to 6.54 euros/hr. This is also close to the recent value obtained by (Schakenbos et al,2016) using the NS panel. For social, recreational and other trips they found VOTTS between 4.31 and 7.86 euros/hour depending on income level. The official VOTTS of the Netherlands for leisure and other trips by train is 7.00 euros/hour(Significance,2013) or 7.75 euros/hr in 2017 euros. This is also another validation of results.

The model fit also shows that the binary logit model fits the data fairly well. This implies a better understanding of the SP of the main survey by respondents compared to the pilot survey which had a poor model fit.

5.7.3. Value of Activities

The value of activities ranges from 4.67 to 5.31 euros/hour for commute trips. There seem to be no significant difference in the value of activities between commuters who read, work or listen to music. One would expect that the value of working is substantially more than that of reading and listening to music since work is usually a paid activity. However, this is not the case. The reason for the same value for all three activities could be because it is their favourite (preferred) activity while travelling.

The way the experiment is set-up, the value of the activity is self-determined by the individual by using the travel conditions and his own personal intrinsic value for that activity. There is no actual trade-off between cost and the ability to perform a certain activity. This means that those who read considers their reading just as valuable as those who work even though the physical monetary reward for reading is zero. This is could also be the case for those listening to music whose value would have been expected to be zero as well.

One explanation for the lower than expected value for working could be that the train environment does not support working with 100% efficiency as you would have in the office hence commuters who are working do not get the full proportion of the actual value of working . This supported by the fact that only 6% of those working considered the train as the ideal place for working. Perhaps, working can have a bigger impact on VOTTS if the train environment is made conducive enough for working. The value of reading and listening to music could already be close to their full value since the efficiency of these two activities is higher than that of working. As a comparison 69% of people listening to music consider the train convenient for the activity, 52% of those reading consider the train convenient for reading while only 25% consider the train convenient for working. So, even though there is no visible difference in values, it possible that people already took the efficiency of performing the activity on the train in their valuation of the activity.

For leisure trips, only the value of reading is significant. Value of working or listening to music during a leisure trip is essentially zero. The explanation for this could be that the activity in a leisure trip is not so much a routine compared to the activity performed during commuting. This means that the traveller can easily switch to other activities in case they are not able to perform the preferred activity. Note that this does not mean that the activity has no real value but rather the value is more or less the same as the value of another activity. It is noted that although reading has a value for leisure, the value could be much lower than the results indicate, because the scale parameter for the SP without activity appears to be significant at almost 5% level.

5.7.4. Value of Travel time savings without preferred activity (approximation for the Value of unproductive/unpleasant travel time savings)

Although the value of a completely unproductive trip (i.e. with no activity at all) was not calculated in this survey, the VOTTS when travellers are not able to perform their preferred activity can give an indication of how important activities are to travellers' VOTTS. To calculate this value of time, the VOTTS with activity is added to the value of the preferred activity. The results are presented below:

Table 5-18: VOTTS for Commuters

Commute	Reading	Working	Music
VOTTS with activity(€/hr)	11.22	12.72	10.08
Value of preferred activity(€/hr)	4.82	5.31	4.67
VOTTS Without preferred activity(€/hr)	16.04	18.03	14.75

Table 5-19: VOTTS for Leisure travellers

Leisure	Reading	Working	Music
VOTTS with activity(€/hr)	4.11	6.54	5.95
Value of preferred activity(€/hr)	3.02	1.17	0.33
VOTTS Without preferred activity(€/hr)	7.13	7.71	6.27

From the results above, it clear that the VOTTS for commuting trip without preferred activity is clearly higher than the current VOTTS of train commuters in the Netherlands. This confirms that people take the activity into consideration in their VOTTS.

Across activity of commute trips, the value of time of people working appears to be highest even whether they are able to work or not. On the contrary, the value of time of people listening to music is the lowest with or without music. Commuters who were reading have higher value of time compared to those listening to music. This is also what (Ettema and Verschuren ,2007) found. As discussed in the literature review, comparing VOTTS across activity patterns does not give information on the value of activities. As can be seen from the results of the commuters, their VOTTS with activities are different but the value of reading, music and working are quite close confirming that the difference in VOTTS is not necessarily due to the activity because different people are compared (we address this later in section 5.7.7). It is only when the same people are compared that the value of activities can be calculated. ***This is the main difference between this research and other previous research on the value of activities***.

Finally, the VOTTS of leisure trips without activity are very close to the current national value (around 7euros/hour). This could indicate that activities of leisure trips do not affect VOTTS that much compared to activities of commuting trips (which are more of a routine). Reading is the only leisure activity which tends to have an impact on VOTTS of leisure travellers.

5.7.5. Worthwhileness rating and value of activities

The worthwhileness rating of travel time with and without preferred activity indicated that travellers had strong preference for certain activities especially working and reading compared to listening to music. However, the results from the values of activities does not fully reflect this difference in preference as the value of all three activities were almost the same. Also, people gave high ratings to working and listening to music on leisure trips but the value of these two activities was not significant for leisure trips. So, the expected correlation between worthwhileness rating and value of activities is not apparent from these results. It could be that people do have strong preference for the activities but it does not really determine the level of impact on their VOTTS.

5.7.6. Summary

The main conclusion that can be reached from the results above is that activities like reading, working and listening to music are valuable to commuters and thus have an impact on their VOTTS. Since commute trips are routine trips, the activities the travellers engage in have also become a routine. This implies that removing the ability to perform these activities during their trip could result in significantly higher VOTTS. For leisure trips activities still have value but there is no specific preference for the activity especially for working and listening to music. Only Reading appears to be the most valuable activity during a leisure trip although it not as valuable as reading during a commute trip.

Even though value of activities is almost the same for all three activities, VOTTS of commuters listening to music could differ from those working or reading because of age, education level, income or another social-demographic variable. Since, we found a significant relationship between socio-demographic and activities using chi-square test, we can check if the difference in VOTTS is related to these variables by looking at interaction between VOTTS and these variables across all commuters. This is done in the next section.

5.7.7. Binary Logit with interaction

To check possible interaction of socioeconomic variables with VOTTS and value of activities a binary logit model with interaction is estimated. Commuters were chosen instead of leisure because all three values of activities were significant and almost the same. So, it is easier to compare results with those of the binary logit model.

It was decided to combine all commuters regardless of activity type for two reasons. First a separate model per activity type will only show which variables are significant for the VOTTS with that activity only and not for commuters in general(see appendix for results of separate interaction models) . So, it does not answer the question why those listening to music have lower VOTTS compared to those working or reading. Secondly, because the estimated separate models per activity type did not yield interaction with the value of

activities. For these reasons, all commuters who read, work and listen to music are combined together in order to find which socio-economic variables have a significant effect on their VOTTS and value of activity. This could explain the difference in VOTTS between those who read, work and listen to music.

Procedure and coding of variables

The coding used is dummy coding with factor coefficients (see section 4.5.3 for explanation). The factor coefficient shows how much the reference VOTTS and value of activity increases or decreases due to interaction with a categorical variable. Many variables were interacted with the VOTTS and the value of the activity. This is to ensure that the model captures any possible interaction with relevant socio-demographic variables like age, gender, education level, income etc. Also, variables like ticket payment, trip duration, activity, duration, transfer etc were also interacted. The reference categorical variables were chosen such that negative and positive factor coefficients can be easily interpreted. After running model with all variables, the significant variables at 5% level were chosen. Then model is then re-run with these variables. This process is repeated until a final model were all variables in the model are significant at 5% is found. (Please see appendix for all variables that were interacted including their reference levels).The final model with variables which were found to have significant interaction with the VOTTS is given below:

$$V_i = \mu\left(\beta_c * TC_i + \beta_c * VOT_{ref} * A * TT_i + CON_{ACT} * \beta_c * \Delta VOT * TT_i\right) \quad (12)$$

$$A = (1 + facEdu_{low} * EDU\_LOW + facINC_{high} * INC_{HIGH} + facTIC_{payfull} * TIC_{payfull} + facTIC\_No\_pay * TIC\_NO\_PAY)$$

Where $CON_{ACT} = \begin{cases} 0 & if\ SP\ with\ Activity \\ 1 & if\ SP\ without\ Activity \end{cases}$

$$\mu = \exp(\gamma * CON_{ACT})$$

$facEdu_{low}$ is the factor coefficient for those with education level 1 to 4 on the Dutch scale. while EDU_LOW is dummy variable for low education

$facINC_{high}$ is the factor coefficient for those with more than twice the average income and INC_{HIGH} is dummy variable for high income earners(more than twice average).

$facTIC_{payfull}$ is the factor coefficient for those who pay full ticket price and $TIC_{payfull}$ is the dummy variable for those in this category.

$facTIC_{no\_pay}$ is the factor coefficient for those who employers pay full ticket price and TIC_NO_PAY is the dummy variable for those in this category.

Table 5-20: Categories of Significant variables

Income	Education Level	Ticket
Below average	Low: level 1-4	I pay myself
About average(Ref)	Medium: level 5-7(Ref)	Employer pays half(Ref)
1-2 times average	High: level 8 and above	Employer pays full
More than twice average		Others

Note that, interaction of variables with value of activities did not yield any significant variable. It appears that variables only interact with the initial VOTTS with activities and not the value of activities. This is expected because the result from the binary logit models already show that the value of activities for all commuters is more or less the same. So even though the respondents who read, work or listen to music differ in terms of socio-demographic variables, everyone values their favourite activity. For example, a low-income person can change VOTTS from 4 €/h to 8€/h while a high-income person can change from 16€/h to 20€/h. The difference is still 4€/h so the value of the activity stays the same even though the income is clearly different. Since we compared same people to calculate the value of activities, only the difference in VOTTS (with and without activity) matters!

Also, it was expected that trip duration will affect value of activities. Since people on longer trips usually have more time for activities compared to shorter trips. However, it is possible that people just value the intrinsic value of the activity instead of the trip itself. Also, the chi-square test for trip duration and activity type did not yield any significant relationship. Which could mean that these three activities are quite popular on all trip lengths. Another possible explanation for why trip duration was not significant is that people were assigned trip length randomly and not according to their normal trip duration. In the survey, they were asked to imagine that they were making a trip of that length.

Table 5-21: Binary Logit model with interaction(Commuters)

N=384,Rho-square=0.141				
Name	Value	Std err	t-test	p-value
BETA_TC	-0.304	0.0206	-14.75	0
ΔVOT(€/hr)	4.884	0.0124	6.59	0
fac_EDU_low	-0.504	0.119	-4.24	0
Fac_INC_ High	0.682	0.119	5.75	0
Fac_TIC_pay	-0.339	0.0822	-4.12	0
Fac_TIC_no_pay	0.443	0.0926	4.79	0
VOT_ref(€/hr)	9.54	0.00965	16.5	0
gamma	0.0677	0.0933	0.73	0.47

The combined value of all three activities after interaction is 4.88€/hr which is not very different from the individual values of activities. This again confirms that the value of reading, working and listening to music do not necessarily depend on the socio-demographic variables.

Education level

In terms of VOTTS with activity, commuters with lower education level (below level 5 in the Dutch education level classification) had around 50% lower VOT compared to the reference which has education level between 5 and 7. The Higher education levels (8 and above) did not have significant interaction indicating that their VOTTS is not significantly different from the reference level. This is consistent with the results also found in the national value of time study(Significance,2013). For instance, they found a reduction of 47% for those with primary school as highest education level compared to university degree. Although, the difference in education level in the research of significance is bigger than in this research, the results show that education level plays a role in VOTTS.

Income

In terms of income, only those commuters with more than twice the average income has a significantly different value of time compared to the reference income level (which was the average income). The VOTTS of those in this income category is 68% higher than the VOTTS of average income earners. For the other income categories, below average and 1-2 times the average, we did not find any significant interaction with VOTTS. This could be because of the vagueness of the categories as they are all close to the average income. Nevertheless, the difference in VOTTS for very high-income earners is still very clear. This is also consistent with previous research on VOTTS which have found higher VOTTS for people with high income. For example, the national value of time study found an almost linear relationship between income and VOTTS. Also recent research using the NS panel (Schakenbos et al ,2016) found VOTTS 10.38euros/hr for average income earners (2000 to 3000 euros gross monthly salary) and 16.16 euros/hrs for high income earners (3000-6000 euros gross monthly salary) . Using the the results above as comparison, the average income earner has a value of time of 9.54 euros/hr while the value of time for high income (more than twice average) is 9.54*1.68=16.02 euros/hour. As can be seen, these values are almost the same with those found by (Schakenbos et al ,2016).

Ticket

The person who pays for the travel ticket has a significant interaction with the VOTTS. Those who pay fully for their ticket have a lower value of time (around 35% lower) compared to those who pay only a portion of the ticket which is the reference. Those who don't pay at all for ticket have a 44% increase in VOT in value of time compared to those who pay a portion of the ticket. These results are expected because those who don't pay for travel ticket should have higher VOTTS because cost is not a real issue.

Age

Surprisingly, age was not found to be significant at 5% level for both VOTTS with activity and value of activity. In the initial model, those with age 55 years and above had lower value of activity compared to the younger age group (35-54). However, the p-value was 0.08 so it was excluded. It is possible that age plays a role in value of activity but probably not very significant.

VOTTS by categories

Using the reference VOTTS of 9.54 euros/hr and factor coefficients found, the VOTTS of commuters of various categories can be summarised as follows

Table 5-22: Final segmented VOTTS of commuters based on significant interactions

Category	VOTTS
Low education	4.37 (€/hr)
Twice the average income	16.02 (€/hr)
Pays price of full ticket	6.31 (€/hr)
Employer pays price of full ticket	13.77 (€/hr)
All others(Reference)	9.54 (€/hr)

5.7.8. Summary

Although value of activities of commuters for all three activities were almost the same, the VOTTS with and without activity (table 5-18) showed some differences (lowest for music, followed by reading and then working). From the analysis above, it possible that these differences in VOTTS is dependent on the education level, income and ticket payment. All these three variables were found to also have significant relationship with the activity reading, working and listening to music using the chi-square test. So, for example, the lower VOTTS for those commuters listening to music compared to those who work or read could be partly explained by the differences in income, education level and ticket type between these people and not necessarily because of the activity. As stated before, (Ettema and Verschuren,2007) also found that commuters listening to music had lower VOTTS compared to those who read. This again shows that comparing the VOTTS of different people does not really give information on the value of activities but rather the comparison should be made between same people as is done in this thesis.

5.7.9. ML panel with Interaction

The binary logit model results with interaction above, does not include random taste heterogeneity. The differences in VOTTS of those working, reading and listening to music could also be because of unobserved random taste heterogeneity and not necessarily because of the activity itself. In order to capture this effect and also take into account the panel structure of data, a panel mixed logit model is estimated.

Different distributions were used to test the existence of heterogeneity in VOTTS and also value of activities (see section 4.5.4 for a discussion on distributional assumptions). The unconstrained distributions of normal, triangular and uniform distributions gave similar results to binary logit model with significant improvement in model fit (around 0.30). However, they yielded significant share of negative VOTTS (ranging from 15% to 30%). A lognormal distribution was also used but the this resulted in high standard deviation (around 18€/hr for VOTTS wit activity and 24€/hr for value of activity). These values were considered too high compared to expectation so were not used.

Thereafter, different constrained distributions were tried. The constrained lognormal, triangular and uniform distribution had a significant effect on the value of activities. The smaller the spread, the smaller the value of activities. So, this was not used to avoid misinterpretation of results. The constrained normal distribution also had an effect on the value of activities but this effect was minimised. The VOTTS and the value of activities were still within reasonable values. It was therefore decided to use a constrained normal distribution. The standard deviation of the distribution was constrained to half the mean. This ensures that less than 2.5% share will have a negative VOTTS. Other constraint yielded unrealistic results or poorer model fit so this was a good choice. Although, negative VOTTS is undesirable, for practical purposes the 2.5% percent can be considered negligible.

Starting from 25 draws, the number of draws were gradually increased by doubling to,50, 100 and 200 etc. The model parameters were reasonably stable with 200 Halton draws. The final results are presented below:

Table 5-23: Panel Mixed Logit models with interaction(Commuters)

N=384, Rhosq=0.293				
Name	**Value**	**Std err**	**t-test**	**p-value**
BETA_TC	-0.699	0.046	-15.2	0
ΔVOT(€/hr)	4.63	0.00913	8.46	0
fac_EDU_low	-0.454	0.121	-3.73	0
Fac_INC_ High	0.504	0.164	3.08	0
σVOT(€/hr)	5.59	0.00458	20.33	0
σΔVOT(€/hr)	2.32	0.00456	8.46	0
Fac_TIC_no_pay	0.659	0.113	5.85	0
VOT_ref (€/hr)	11.16	0.00916	20.33	0
gamma	-0.0474	0.0995	-0.48	0.63

The estimated mean parameters for the reference VOTTS(11.16€/hr) and ΔVOT (4.63€/hr) are reasonably close to that of the binary logit model with interaction. Compared to the reference VOTTS, those with low education level have around 45% lower VOTTS, high income earners have about 50% higher VOTTS and those who don't pay for their ticket have around 66% higher VOTTS. These results are also not much different from the binary logit model. However, the model fit (0.293) is better than that of the binary logit model with interaction (0.141). This indicates that there is a gain in model fit because of the ability to capture random taste heterogeneity in both the VOTTS and the value of activities(ΔVOT). This means that although taste variation in VOTTS is partly explained by observed differences in income, education level and ticket type, there is still some unobserved taste heterogeneity which the model captures. Note that even though, there is a percentage of people (2.3%) with counter-intuitive VOTTS and ΔVOT, this is accepted in exchange for a better representation of random taste heterogeneity in the sample.

5.8. Validation of Methodology

The SP experiment performed was carefully designed to avoid bias in results (especially those related to the difference in VOTTS with and without activity. The following bias were excluded:

1) Bias relating to crowding and general train environment were excluded by making the experiment about the inability of the respondent to perform the preferred activity because they forgot the equipment needed.
2) Bias related to comparing VOTTS of different people was removed by using the same set of people. So same people but different context.
3) Distance classes were used to prevent bias related to respondents seeing exactly the same choices twice and just filling in the opposite or same.
4) Distance classes were balanced among context (with and without activity) to avoid effect of trip and activity duration.
5) The order of the SP was randomised to avoid order effect.

Even though all these biases were removed from design, there is still a possibility that results were biased by which SP respondents saw first or second. The hypothesis used for designing the experiment was:

The VOTTS of same people should remain the same even if they did the same survey twice. So, the VOTTS of respondents within a group should not significantly change unless the context with and without activity plays a role.

To verify this hypothesis and the methodology used for the survey, it is possible to check whether the VOTTS for the first 6 series of choice tasks (regardless of context and

distance class) differs from the VOTTS of the second series 6 of choice tasks(regardless of context and distance class). These two VOTTS should be reasonably close since the context has now been removed (i.e. no more reason for VOTTS to change). The combined SP of all commuters who read, work and listen to music to verify this since they all had a significant change in VOTTS. The results are presented below:

Table 5-24: VOTTS based on the first and second series of choices.

FIRST SP (obs.=2304, N=384, rho-sq=0.095)				
Name	Value	Std err	t-test	p-value
BETA_TC	-0.276	0.0222	-12.42	0
VOT(€/hr)	14.16	0.0106	22.22	0
SECOND SP (obs.=2304, N=384, rho-sq=0.12)				
BETA_TC	-0.306	0.0205	-14.87	0
VOT(€/hr)	13.50	0.00834	27.01	0
Combined both SP (obs.=4608, N=384, rh-sq=0.108)				
Name	Value	Std err	t-test	p-value
BETA_TC	-0.292	0.0151	-19.39	0
VOT(€/hr)	13.80	0.00656	35.01	0

Table 5-25: Change in VOTTS due to the order of SP survey

Difference in VOT when context is removed (obs=4608, N=384,rh-sq=0.108)				
Name	Value	Std err	t-test	p-value
BETA_TC	-0.306	0.0205	-14.87	0
ΔVOT(€/hr)	0.63	0.0135	0.78	0.44
VOT(€/hr)	13.5	0.00834	27.01	0
gamma	-0.103	0.105	-0.98	0.33

Table 5-26: Change in VOTTS due to context

Difference in VOT due to context with and without activity (obs=4608, N=384,rh-sq=0.118)				
Name	Value	Std err	t-test	p-value
BETA_TC	-0.29	0.0207	-13.98	0
ΔVOT(€/hr)	5.00	0.0138	6.03	0
VOT(€/hr)	11.46	0.00768	24.85	0
gamma	0.0317	0.104	0.31	0.76

Table 5-27: change in VOTTS of 6 choices compared to 12 choices

	Change in VOT compared to 12 choices (€/hr)
First 6 choices people made	0.36
Second 6 choices people made	-0.30

Table 5-28: Significance of change in VOTTS

	Change in VOT (FIRST and SECOND choices) (€/hr)	Change in VOT (due to activity) (€/hr)
Value	0.66	5.00
Significant at 5% level	No	Yes

Table 5-29: Summary of results

SP (commute read, work and music)	VOT(€/hr)
First 6 choices people made	14.16
Second 6 choices people made	13.50
Combined 12 choices	13.80
with activity	11.46
without activity	16.46

From the results above, it is clear that the change in the VOTTS of commuters who read, work and listen to music is not because of the SP they saw first or second but because of the importance of the activity. When the context of activity is removed, the change in VOTTS drops from 5.0(€/hr) to just 0.66 (€/hr). Also, the number of choice task did not play a significant role in VOTTS of respondents. So, their VOTTS with only six choices is almost the same with the VOTTS with 12 choices. This means that their VOTTS did not change because they did the same survey twice. This confirms that the hypothesis used to design the survey is correct. It also serves to validate the survey design methodology.

CHAPTER 6: CONCLUSION

6.1. Main findings

6.1.1. Impact of activities on VOTTS

It has been long postulated that the ability to perform activities has an impact in VOTTS. This research confirms it. Specifically:

1) Activities such as reading, working and listening to music have a significant effect on travellers' VOTTS (especially for commuters). The direction of impact of these activities is also very clear i.e. these activities reduce the VOTTS and not the opposite. All values of activities were found to be positive indicating that preferred activities are not randomly chosen.
2) The current official VOTTS of commuters and leisure travellers in the Netherlands are close to the VOTTS with activity found in this study. This indicates that travellers could already take the ability to perform certain activities into account in their current VOTTS. So, without the ability to perform certain activities like reading, working and listening to music, the real value of time of commuters for example will be about 5euros/hour higher than the current value.
3) The hypothesis that travellers value time less negatively when performing activities compared to when they are not, is true for some activities and trip purpose combination. Reading reduces VOTTS for both commuters and leisure travellers while working and listening to music reduces the VOTTS for commuters only. There is an indication that activities have more value for commute trips compared to leisure trips.
4) People rate their travel time as more worthwhile when they able to perform certain preferred activity compared to doing something else. So, there is a clear ordering of activities. Also, travel without doing anything is rated lower compared to doing something. This indicates that people will rather choose an activity to do during a trip rather than spend the travel time doing nothing and also that they prefer to do certain activities.
5) Socio-demographic variables like age, gender, income education level, etc have a significant relationship with the preferred activity. However, the value of the activities as calculated in this thesis does not necessarily depend on these socio-economic variables but it is based on the individual self-evaluation. This indicates that travellers select activities they enjoy as preferred activity.

6.2. Answer to main research question

What effects does the ability to perform activities during travel have on a travellers' VOTTS and how can these effects be modelled and quantified

The ability to perform certain preferred activities like reading, working and listening to music during travel reduces the VOTTS especially for commuters by about 5euros/hour. For leisure traveller reading was found to reduce the VOTTS by about 3euros/hr.

To model and quantify these effects, the specially designed self-engagement SP experiment proposed in this thesis can be used. Based on the results found in this thesis, corrections and modifications can be made to the current VOTTS to include activities performed during travel.

6.3. Main contributions of research

1) Provides a survey design methodology for calculating the monetary value of activities performed during travel. The survey design method proposed in this thesis fits nicely with existing theories and survey design methods currently being used. This makes it easier for understanding, interpretation of results by researchers and practitioners in the field. Also design methods can easily be replicated making it easier for other researchers to validate results.
2) To the best of the author's knowledge this is the first research that confirms via SP that travellers take into account the ability to perform activities when travelling in their VOTTS.
3) Introduces the concept and definition of the value of productive/pleasant travel time savings and the value of unproductive/unpleasant travel time savings. This helps to distinguish between the value of time as is currently known and the value of time with and without activities. This distinction has not been explicitly made before.

4) Provides a way to separate the negative and positive benefits of travel (i.e. ability to be productive or have a pleasant journey)
5) Provides a way to quantify these positive benefits of travel in societal CBA of transport.

6.4. Possible impact and use of research results

The results found in this thesis could have potential impact on different aspect of transport project evaluation both from a policy point to a commercial and practical point of view. In the next sections, some of the potential impacts and use of results are examined.

6.4.1. Transport Investment and Policy implications) : Speed vs Journey experience

The diagram below describes the whole journey experience of a traveller (i.e. door to door appreciation of time). The x-axis represents the total spent on the journey, and the y-axis represents the value(appreciation) of that time. As can be seen, the time at the origin and destination are appreciated more since it can be used productively and pleasantly as the case maybe. After this, the next most valuable time is the in-vehicle time. For most journeys, this is the longest part. Access, egress and transfer are the least appreciated time.

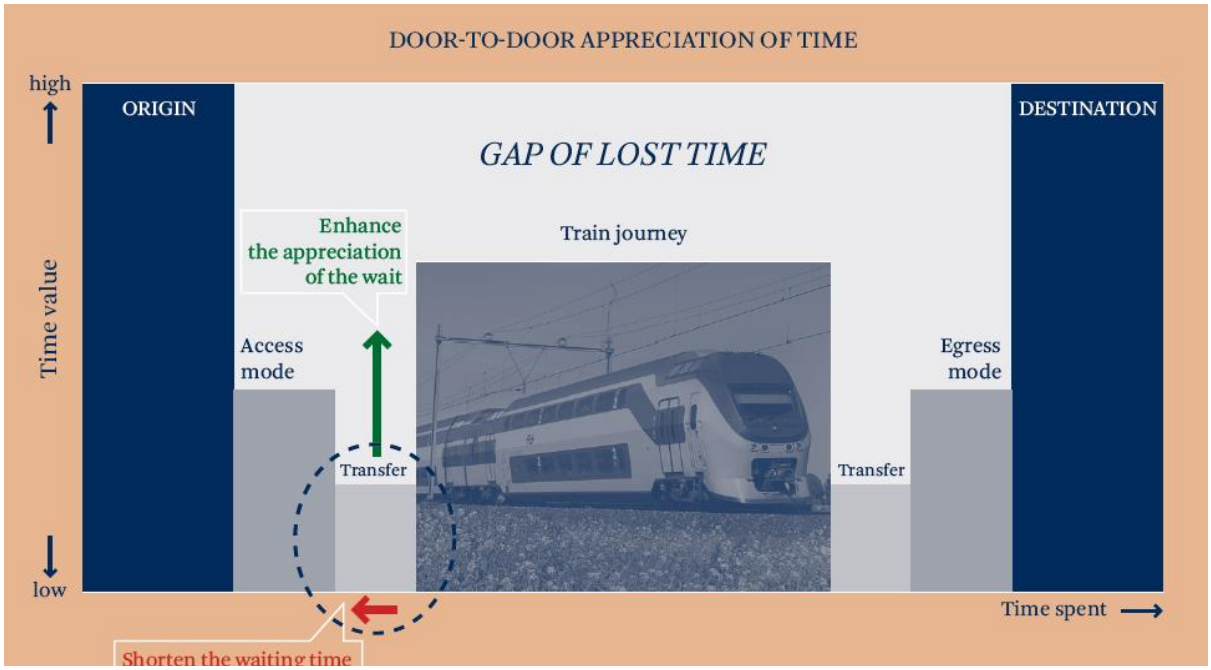

Figure 6-1: Door to door appreciation of time Source, van Hagen 2011

The ideal situation will be that all travel time is appreciated the same way at as the time spent at the origin and at the destination. In this case, the total door to door appreciation of time will be the area of the rectangle filled with all blue colour (i.e. total time spent multiplied by its value). This means that the VOTTS will be equivalent to zero i.e. there is no gain in saving travel time. In fact, if all the rectangle is blue then reducing travel time will amount to reducing the area of the rectangle (i.e. the total door to door appreciation of time).

The fact that travel is a disutility makes it virtually impossible for all areas in the rectangle to be blue. The consequence of this is the gap of lost time due to travel (white spaces in the diagram). The area of these white spaces can be considered as the lost value in total time appreciation.

How to reduce the white spaces

Option1: X-axis (reduce the total journey time)

This is the classical way of reducing lost time due to travel. To do this, we can simply just shorten the waiting time (increase frequency), reduce transfer time (provide more direct

connections) or reduce the in-vehicle time (invest in trains with higher speed). Although, this sounds like a pretty straightforward solution, the costs are usually very high. In most of the cases, these aforementioned solutions require investment in new trains (assuming that you want to keep satisfy existing demand).

Option 2: Y-axis (improve the appreciation of travel time)

Another way to reduce the white space in the diagram is to improve the appreciation of travel time along the Y-axis. This could be done by making it possible for travellers to use their travel time in a productive and pleasant way as they would have if they were at their origin or at their destination. There has been some research on improving the waiting time experience at train stations (see for example van Hagen 2011). In Hagen's research, it was shown that people who had something doing while waiting for the train perceived the time faster than those who were idle. So, engaging in activities while waiting could potentially improve the appreciation of the waiting time. In-vehicle time can be viewed as an extended waiting time to get to the destination (albeit on a moving train). This research on the impact of activities on the VOTTS revealed that when travellers are engaged in certain activities (e.g. reading, working, listening to music) they have a lower VOTTS i.e. they appreciate the travel time more when they are able to perform their preferred activity compared to when they are not. This suggests that investments which will improve travellers' ability to perform preferred activities while travelling can further help increase their appreciation of travel time.

Choosing among the two options

Traditionally lost time in travel is considered unproductive and thus should be reduced. Using this notion, it should be pretty straightforward which investment decision is better. However, times have changed and travellers are now making productive and pleasant use of their travel time as this research and others have revealed. So, the question of whether to make the journey faster or make the experience better (with the ability to be productive) is a valid one. Budget constraints usually means that investment is geared towards the cheapest option. As discussed before, investments in speed are easier to calculate once the new and expected travel time is known. The improvement in travel time is multiplied by the VOTTS to get the monetary gain. For investment which improves travellers' ability to be productive during their journey, there are no straightforward calculations because the travel time stays the same. However, using the value of activities, it could be possible to calculate the monetary gain in such investments. For example, the change in the productive time can be multiplied by the value of productivity to get the monetary gain of investment in productivity.

$$Speed\ Benefit = \Delta Total\ Travel\ time * VOTTS$$

$$Reading\ benefits = \Delta Total\ Reading\ time * VoReading$$

Where $=\Delta Total\ Travel\ time$ is the expected change in total travel time after the speed improvement.

$VOTTS$ is the current value of travel time savings

$\Delta Total\ Reading\ time$ is the expected change in total reading time during a journey after the improvement in reading facilities.

$VoReading$= Value of reading as calculated in this thesis

Once the costs for both investments are known, then the one with the highest net benefit can be chosen. The two options both have their advantage and disadvantages. The improvement on travel time is easily calculated using simulation (e.g. VISUM) with reasonable accuracy. The disadvantage is that cost for travel time improvement could be an order of magnitude larger than the costs for improvement in productivity. On the other hand, the change in the total reading time cannot be simulated. So, it can only be a rough estimation. The actual change in reading time can only be calculated after the investment has been made. To overcome this problem, stated preference survey can be carried out to get rough estimate of how much the reading time will change given a certain comfort level.

6.4.2. The societal benefits of travelling by train

NS trains provide opportunity for people to engage in activities while travelling. This research has shown that activities have monetary value and hence can be considered a benefit to the society. The societal benefit can be calculated as follows:

$$Societal\ benefits\ of\ a\ train\ journey = \sum_{All\_Activities} Total\ activity\ time * VoActivity$$

$VoActivity$ is the monetary value of the activity as calculated in this thesis. This could be an added advantage of travelling with the train compared to the car.

6.4.3. Value of Comfort and crowding

Crowding

Currently the only way to consider possible loss in productivity of a journey is through the value of crowding (Björklund and Swärdh,2015; Whelan and Crockett,2009; Kroes et al,2013). Although crowding inhibits productivity, it does not tell us how productive people actually are when there is no crowding at all. The current VOTTS are multiplied by crowding coefficient to account for crowding. This coefficient ranges from 1.21 to 2.37 depending on the level of crowding. This gives rise to higher VOTTS. However, this high VOTTS is not corrected for the productivity and pleasantness of a train journey. Since the train is not crowded all the time, the value of possible productivity and pleasantness of the journey should be subtracted from the final VOTTS savings after correcting for crowding.

If we divide the VOTTS without activity and with activity, it is possible to get a coefficient comparable to those of crowding coefficient. For example, the average VOTTS

with activity for all commuters is 11.46€/hr while without activity, it is 16.46€/hr . This leads to coefficient of 1.44 which is within the range of crowding coefficients found in Whelan and Crockett,2009; Kroes et al,2013). It is possible that some of the negative effects of crowding are related to passengers' inability to perform certain preferred activities. This needs to be investigated.

Comfort

To calculate the value of comfort, VoC, Warffemius et al (2016) used the result of Mott McDonald (2009) for Business passengers which found that there is a 50% reduction of travel time savings for business passengers, because they can spend the travel time in a useful way. They then used seating capacity based on research conducted by NS. In this research respondents with different trip types were asked if they had spent their time in a useful way, and also in the way they wanted to spend their time. By applying these proportions to the result of Mott McDonald for Business passengers, they found relative comfort values ranging from of 35% reduction in VOTTS on average. From this, they estimated the VoC to be equal €5.00 per hour. This is close to the change in VOTTS for commuters who work, read and listen to music which ranges from (4.67€/hr to 5.31€/hr) . This is another indication that the VoC could be closely related to the value of activities and serves as a way of validating the results for the value of activities.

6.4.4. Automated vehicles scenarios

The VOTTS is widely used in CBA of transport investments. The current VOTTS assume that travel time is lost since a driver cannot make productive use of their time. This means that the VOTTS for cars will be close the value of unproductive travel time because most car travel time cannot be used for most activities (eg. working, reading). The scenario of the future in which automated vehicles are expected to be used on the road requires special attention. It can be argued that the VOTTS of an automated vehicle driver is not the same as a manual car driver. The results of this research indicate that the VOTTS could be lower for those who use automated vehicles because of the added advantage of the ability to perform various activities while travelling. In the future, new VOTTS will have to be estimated for automated vehicle drivers only because their VOTTS will be clearly different. Also, there has to be a new definition of hours lost in traffic jams. Currently all time spent in traffic is considered lost time and majorly used to justify the construction of new roads after the conversion to monetary gains using the VOTTS. However, with the scenario of automated vehicles, time spent in traffic could be used for productive activities so not all the times will be lost. This needs to be investigated in the future

6.5. Practical recommendations

6.5.1. Recommendations for NS

There is ample evidence from this research that passengers are enjoying their trip more when they able to perform their preferred activities. This mean that NS should pay more attention to activities and especially the train environment. Most activities require that the passenger is able to seat and that the environment is quiet. Therefore, a noisy and crowded train will limit the ability of passengers to engage in activities. Similar to how people react to crowding (Pownall et al., 2008; Davidson et al., 2011; Vovsha et al., 2014) , it possible that travellers will behave the same way so they can perform their activities on the train for instance by departing earlier or later to avoid crowding, using a different line or station to start their journey, waiting for a less crowded trains, upgrading to first class, choosing less crowded carriages(Pel et al, 2014).

Also, there is a possibility that the current train environment is not suitable for all activities especially working with only 6% of respondents saying the train is the ideal place to work. This could be related to crowding or lack of some essential facilities/space required to work effectively as in the office. For other activities such as reading (which is quite popular among travellers) there is still room for improvement because only 24% of people consider the train as ideal place for reading.

Improvement in opportunities for worthwhile use of travel time on the train can be made on three levels. On a strategic level, investment can be made to enable people perform their activities more effectively on the train. For instance, by providing special sections on the train for activities. The sections can be grouped by activity type, for instance reading and working can be in one section, since both need similar amount of concentration and comfort. Activities such as listening to music, use of social media etc can be grouped together since both require similar equipment and comfort. For activities like talking, a meet and talk section can be added to trains. So, passengers can enter the section to meet new people and start a conversation. Other activities like sleeping, relaxing can also have a separate section which should have some dedicated facilities e.g. sleeping beds. or even foldable seats.

These special sections can either be commercialised using passengers willing to pay or provided for free using the monetary value of the activity. For example, passengers can book for these sections just like booking for a first-class seat or buy tickets which allows them use these sections.

On a tactical and operational level, activity patterns per route should be studied. This will make it easier to know which routes should be targeted for comfort and crowding improvement and also improvement in on board facilities for activities. For instance, frequency and departure times can be adjusted on such routes or different types of trains can be used depending on capacity, and onboard facilities to match passengers' needs. Adding more trains on a busy route can make more seat available for people to perform their activities which in turn adds more benefits.

If people can make better use of their time while onboard NS trains, then this gives a competitive advantage to NS. It could potentially attract more people to use the train and also increase customer satisfaction.

6.5.2. Recommendation for KiM VOTTS calculations

As discussed in the introduction to this thesis, the most recent VOTTS study for the Netherlands revealed that VOTTS were lower than expected even after correcting for increase in income. The lower than expected values were partly attributed to the ability of travellers to make productive use of their travel time (Significance,2013, Warffemius et al 2016). The results of this thesis indicate that activities do play a role in VOTTS and it could partly explain why the VOTTS is reducing. If opportunities for engaging in activities continue to improve, then this trend is expected to continue in the near future. It therefore important to incorporate the ability to perform various activities during travel in national VOTTS calculations.

One way to do this, is to distinguish between the value of productive and pleasant travel time and the value of an unproductive and unpleasant travel time. If this is done, it is possible to check if any of these values have changed and by how much. Also distinguishing between these two VOTTS make it easy to calculate the value of activities. These values can then be compared to previous years to see if improvement in travel conditions or ability to perform activities has had an effect in VOTTS. The values of activities can also be used for calculating benefits relating to comfort and improvement in services which allow travellers to make better use of their travel time. As discussed in the previous section(6.4.3) value of activities could be related to value of comfort and crowding. So, any improvement in comfort or crowding could potentially influence the value of activities and the VOTTS.

From a long-term view, this proposed approach of distinguishing VOTTS could be much better than the current way VOTTS is calculated. The way it is now, it difficult to calculate benefits that are related to activities and how these improvements will affect VOTTS in the future. If KiM considers the fact that VOTTS on other public transport modes like bus, tram and metro or even automated vehicles , could be affected by activities as well, then it wise to consider the economic impact of activities performed during travel in subsequent national VOTTS calculations.

6.6. Limitations of Research

The first limitation of the research is that stated preference was used instead of revealed preference. The time and cost values are hypothetical. For example, that people were not assigned SP according to their actual trip duration. They were asked to imagine that they are making a trip of that trip length. So, these values of activities might differ from the ones calculated here. However, since design was balanced with different trip lengths

combined with context the effect of actual trip length might not be that much. However, this is still a limitation.

Also, it is possible that the value of activities is different from the one calculated here since people could still do other things. As discussed before, doing nothing while travelling could be very boring but it is impossible for people to imagine that they travel without doing anything at all. So, this research was not able to measure the VOTTS of a completing unproductive/unpleasant trip with no activity at all.

Another limitation of the research is that the survey design methodology used does not allow for some activities to be valued. Activities that do not require equipment were excluded to avoid introducing bias related to the train environment. So, this research cannot be replicated for such activities eg. sleeping, relaxing.

Another important limitation of the research is that it did not calculate the value of combined activities. For instance, some people could be working and listening to music, or using social media and talking, or even sharing the journey time between two or more activities. The monetary values of this type of combination could be different from the preferred activity. So, this needs to be investigated

Finally, the survey asked people to imagine they forgot equipment required for certain activities. Although this scenario is possible in real life, it is not frequent so most people might not have experienced it before and would not know what to do in that case. This can lead to over valuing or undervaluing the activity. Also, some equipment can be used for various activities so, someone who normally reads a book and forgot it, can still read via a phone for instance. Respondents were also asked to consider only one trip and activity combination only when making their choices. However, it possible that they considered their inability to perform other activities also. Again, this can lead to a different value of the activity since people can still perform the activity or unable to perform other activities.

In terms of model estimation, the mixed logit model used in this thesis is limited by assumptions on the distribution of VOTTS. Imposing a constraint on the distribution also affects results. Therefore, results of mixed logit should be scrutinised more, since they depend on the researcher's selection of distribution and constraints. For instance, another model specification with a different distribution for VOTTS could lead to significantly different results. This is a disadvantage of mixed logit models. Note that the Netherlands's national VOTTS results by (significance,2013) also reported problems in estimation of mixed logit models in VOT space. Thus, the mixed logit model results were completely abandoned. They therefore opted to use a latent class model. So other advanced models like latent class models should be used to further verify results.

In conclusion, values calculated for activities could differ from the actual values because of the reasons discussed above, so there is need to repeat experiment to further verify

results. In the next section, some possible research directions and recommendations are presented.

6.7. Recommendations for Future Research

1. Since research into the value of activities is relatively new so there is a lot to do in the future, more research is needed to verify the methodology and results of this thesis. For example, a repeat study of this research should be done on a larger scale to verify results. Depending on results, there could be a national value of activities calculation for the Netherlands which can be used for CBA of transport projects.
2. Another relevant research direction will be to revaluate current VOTTS. SP surveys should then include ability to perform activities as either context or attributes or even the number of minutes you are able to perform activities. This can be combined with crowding and other comfort attributes to get more realistic estimate of VOTTS. The VOTTS for a productive and pleasant journey should be distinguished from the VOTTS of an unproductive/unpleasant trip to enable value of activities to be calculated.
3. From a commercial point of view, the values of activities should be translated to WTP for activity. This will enable train service providers like NS to exploit any potential monetary gain in providing special services for travellers who want to engage in certain preferred activity. For example, people can choose between their ideal trip (with what they actually want to do), and the current trip (what they are doing) and make a trade-off. This can be used for pricing the tickets of the special sections on the train reserved for activities.
4. Also, it will be interesting to carry out research on what people actually do with their leisure time. For instance, do they read, listen to music or sleep. This will make it possible to know which activities are currently being transferred from home to travel and how much time is saved by performing activities on the train.
5. A methodology to calculate value of activities like sleeping, relaxing, looking outside etc should is needed. For instance, a time perception experiments similar to the experiment performed for waiting time (Van Hagen,2011) can be done. So, people could be asked how much more or less the perceive their travel time while engaging in such activities. This can then be translated to monetary values.
6. Value of combined activities e.g working and listening to music should be calculated as well. This can give more realistic value of activities since people usually don't engage in one single activity throughout the journey.
7. The survey design methodology used in this thesis can be further tested with other effects like crowding. For instance, people make choices between crowded train trips and then again between non-crowded train trips. This can be used to calculate the value of crowding in contrast to what is being done now where crowding coefficients based on passengers WTP to avoid crowding is used. Using the method in this thesis, the values of crowding can be directly compared with the value of activities since

both were based on individual self-evaluation of VOTTS without any actual trade-off .

8. Finally, more theoretical research needs to be done to understand how people choose which activity to perform during travel and what the value of activity depends on. This could help explain some findings in this thesis.

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APPENDIX

A: NGENE CODES

```
Design
;alts = TripA*,TripB*
;rows = 6
;eff = (mnl,d)
;model:
U(TripA) =  TT[-0.0957]*time[10,20,30] +TC[-0.432]*cost[3,4.5,6] /
U(TripB) =  TT[-0.0957]*time[10,20,30] +TC[-0.432]*cost[3,4.5,6]
$

Design
;alts = TripA*,TripB*
;rows = 6
;eff = (mnl,d)
;model:
U(TripA) =  TT[-0.0957]*time[35,50,65] +TC[-0.432]*cost[6,8,10] /
U(TripB) =  TT[-0.0957]*time[35,50,65] +TC[-0.432]*cost[6,8,10]
$

Design
;alts = TripA*,TripB*
;rows = 6
;eff = (mnl,d)
;model:
```

```
U(TripA) =  TT[-0.0588]*time[80,100,120] +TC[-0.259]*cost[8,12,16] /
U(TripB) =  TT[-0.0588]*time[80,100,120] +TC[-0.259]*cost[8,12,16]
$
```

B: BIOGEME CODES

Biogeme Code(Binary logit model which includes change in VOT due to context)

```
[ModelDescription]
[Choice]
CHOICE
[Beta]
BETA_TC         0          -10000          10000        0
VOT              0.1       -10.000         10.000       0
D_VOT              0.1       -10.000         10.000       0
gamma              0          -10000          10000        0

[Utilities]
1    Alt1   av1     $NONE
2    Alt2   av2     $NONE
[GeneralizedUtilities]
1  exp( gamma * CON ) * ( TCA * BETA_TC + TTA * VOT * BETA_TC
+ TTA * ( D_VOT * CON ) * BETA_TC )
2  exp( gamma * CON ) * ( TCB * BETA_TC + TTB * VOT * BETA_TC
+ TTB * ( D_VOT * CON ) * BETA_TC )
[Expressions]
av1 = 1
av2 = 1
```

```
[Model]

// Currently, only $MNL (multinomial logit), $NL (nested
logit), $CNL

// (cross-nested logit) and $NGEV (Network GEV model) are
valid keywords

//

$MNL
```

Binary Logit Model(with no differentiation of context)

```
[ModelDescription]

[Choice]

CHOICE

[Beta]

BETA_TC         0          -10000          10000        0

VOT                0.1       -10.000         10.000       0

[Utilities]

1    Alt1   av1     $NONE

2    Alt2   av2     $NONE

[GeneralizedUtilities]

1   TCA * BETA_TC + TTA * VOT * BETA_TC

2   TCB * BETA_TC + TTB * VOT * BETA_TC

[Expressions]

av1 = 1

av2 = 1

[Model]

// Currently, only $MNL (multinomial logit), $NL (nested
logit), $CNL
```

```
// (cross-nested logit) and $NGEV (Network GEV model) are
valid keywords

//

$MNL
```

Binary Logit with Interaction(Final Model)

```
[ModelDescription]

[Choice]

CHOICE

[Beta]

BETA_TC        0          -10000          10000        0

VOT                0.17        -10.000        10.0000       0

D_VOT              0.17        -10.000        10.0000       0

INC3               0          -10000          10000        0

EDU1               0          -10000          10000        0

TIC1               0          -10000          10000        0

TIC2               0          -10000          10000        0

gamma              0          -10000          10000        0

[Utilities]

1    Alt1   av1     $NONE

2    Alt2   av2     $NONE

[GeneralizedUtilities]

1   exp( gamma * CON ) * ( TCA * BETA_TC + TTA *  VOT * ( 1  +
INC3 * CON3_INC + EDU1 * CON1_EDU + TIC1 * CON1_TIC + TIC2 *
CON2_TIC  ) * BETA_TC + TTA * D_VOT  * CON * BETA_TC )
```

```
2  exp( gamma * CON ) * ( TCB * BETA_TC + TTB *  VOT * ( 1  +
INC3 * CON3_INC + EDU1 * CON1_EDU + TIC1 * CON1_TIC + TIC2 *
CON2_TIC  ) * BETA_TC + TTB * D_VOT  * CON * BETA_TC )

[Expressions]

av1 = 1

av2 = 1

[Model]

// Currently, only $MNL (multinomial logit), $NL (nested
logit), $CNL

// (cross-nested logit) and $NGEV (Network GEV model) are
valid keywords

//

$MNL
```

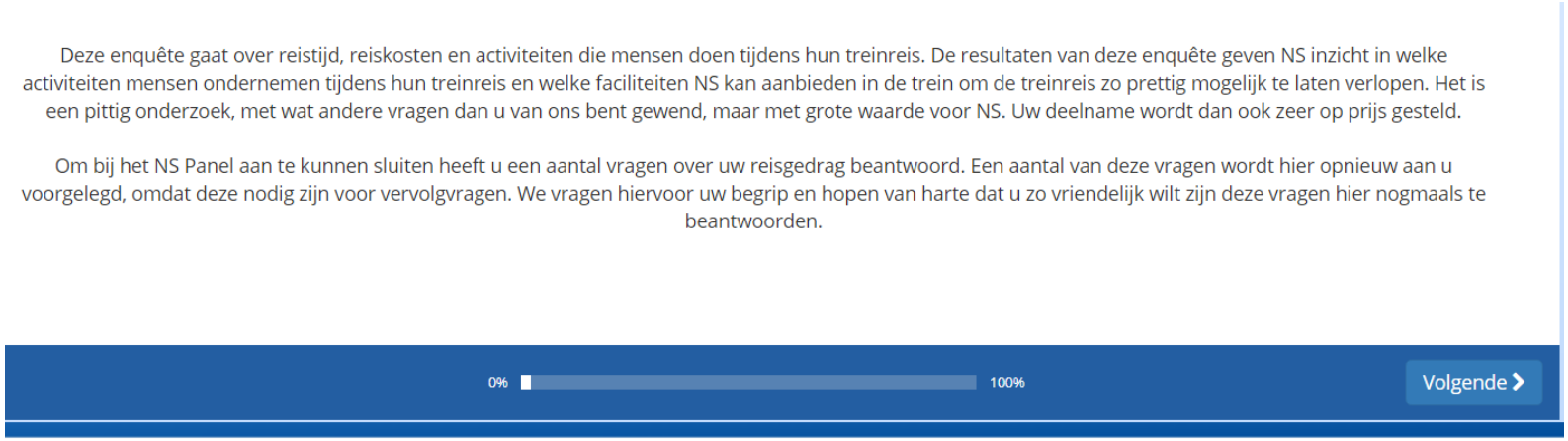
Mixed Logit with interaction (Constrained Normal Distribution)

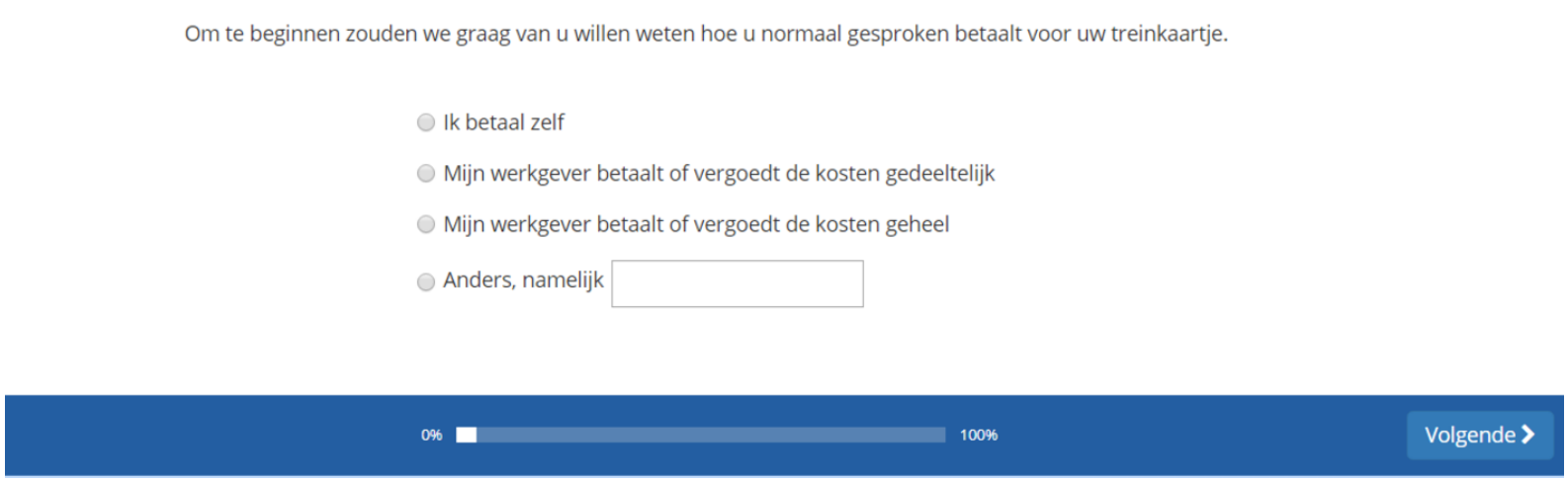
```
[ModelDescription]


[Choice]

CHOICE


[Beta]

BETA_TC        0         -10000         10000       0

VOT               0.17       -10.000       10.0000      0

S_VOT             0.17       -10.000       10.0000      0

S_VOT2    0.17       -10.000       10.0000      0

D_VOT             0.17       -10.000       10.0000      0

INC3              0         -10000         10000       0

EDU1              0         -10000         10000       0
```

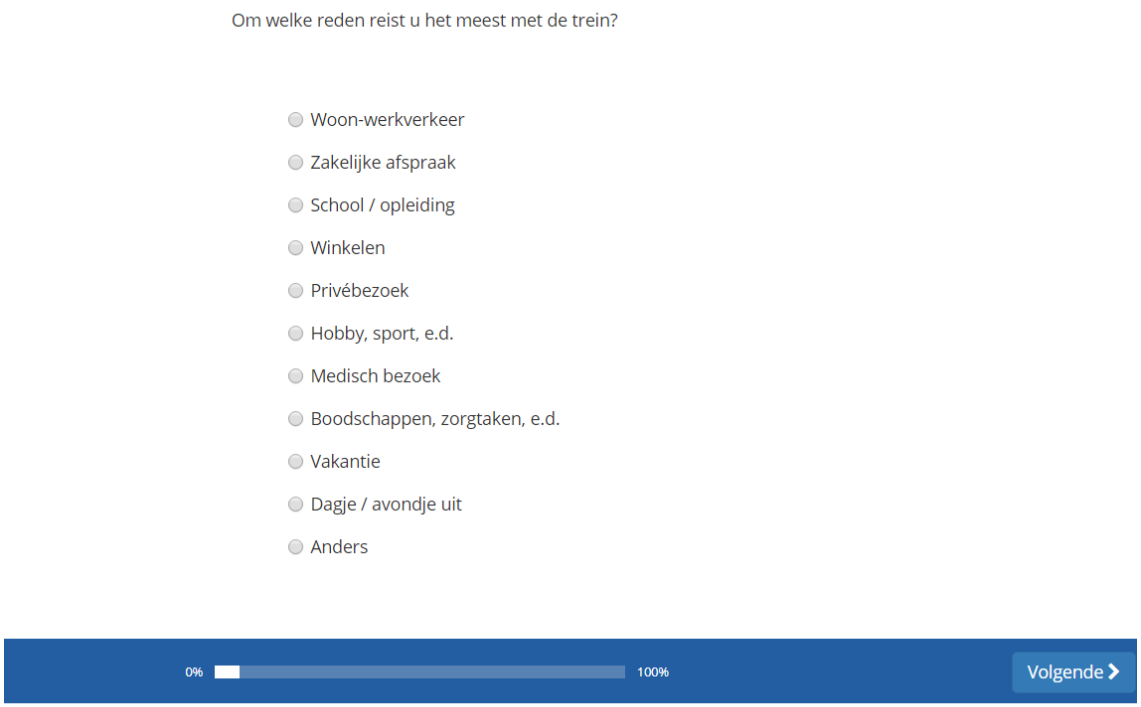
```
TIC2                0          -10000          10000       0

gamma               0          -10000          10000       0

[Utilities]

1   Alt1  av1    $NONE

2   Alt2  av2    $NONE

[GeneralizedUtilities]

1  exp( gamma * CON ) * ( TCA * BETA_TC + TTA * VOT [ S_VOT ]
* ( 1  + INC3 * CON3_INC + EDU1 * CON1_EDU + TIC2 * CON2_TIC
) * BETA_TC + TTA * D_VOT [ S_VOT2 ]  * CON * BETA_TC )

2  exp( gamma * CON ) * ( TCB * BETA_TC + TTB * VOT [ S_VOT ]
* ( 1  + INC3 * CON3_INC + EDU1 * CON1_EDU + TIC2 * CON2_TIC
) * BETA_TC + TTB * D_VOT [ S_VOT2 ] * CON * BETA_TC )


[PanelData]

// ID is the identifier of the individuals in the sample

ID


VOT_S_VOT

D_VOT_S_VOT2




[Expressions]

av1 = 1

av2 = 1
```

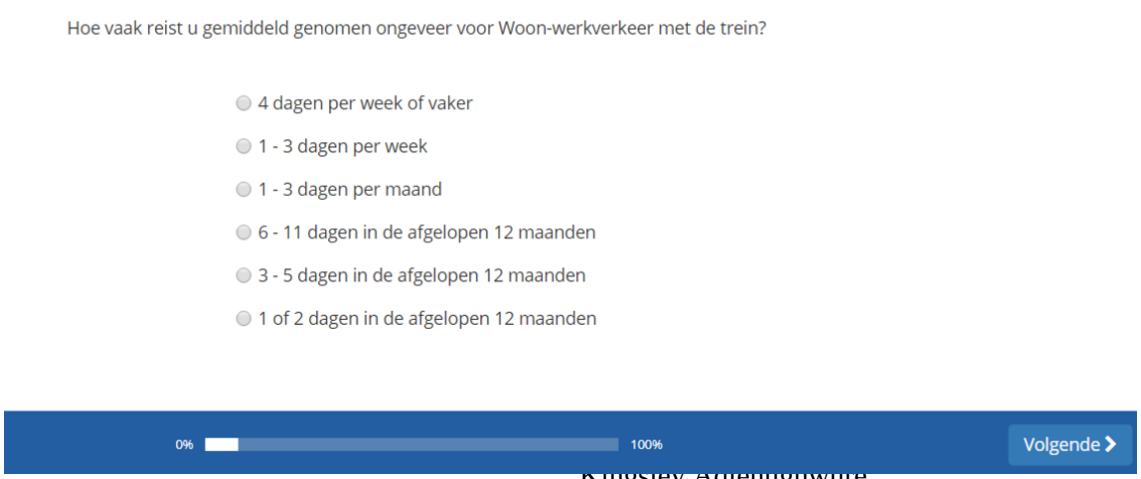
```
[LinearConstraints]

S_VOT - 0.5 * VOT <= 0

S_VOT2 - 0.5 * D_VOT <= 0


[Draws]

200



[Model]

// Currently, only $MNL (multinomial logit), $NL (nested
logit), $CNL

// (cross-nested logit) and $NGEV (Network GEV model) are
valid keywords

//

$MNL
```

C: COMPLETE SURVEY(IN DUTCH)






Om welke reden reist u het meest met de trein?
Woon-werkverkeer
Zakelijke afspraak
School / opleiding
Winkelen
Privébezoek
Hobby, sport, e.d.
Medisch bezoek
Boodschappen, zorgtaken, e.d.
Vakantie
Dagje / avondje uit
Anders
0%
100%
Volgende


Hoe vaak reist u gemiddeld genomen ongeveer voor Woon-werkverkeer met de trein?
4 dagen per week of vaker
1 - 3 dagen per week
1 - 3 dagen per maand
6 - 11 dagen in de afgelopen 12 maanden
3 - 5 dagen in de afgelopen 12 maanden
1 of 2 dagen in de afgelopen 12 maanden
0%
100%
Volgende

Bij het invullen van de volgende vragen willen we graag dat u uw reis voor **Woon-werkverkeer** in gedachten neemt.

Als u uw treinreis voor **Woon-werkverkeer** maakt, maakt u dan een overstap naar een andere trein?
**Met overstap bedoelen we de overstap naar een andere trein en niet naar een ander vervoermiddel zoals de bus of de metro.*

- ○ Ja, altijd
- ○ Ja, meestal
- ○ Nee, meestal niet
- ○ Nee, nooit

Wat is de totale duur **(van vertrekstation tot aankomststation)** als u deze specifieke reis voor **Woon-werkverkeer** met de trein maakt?

☐ Geef aan in **minuten**

De volgende vragen gaan over de omstandigheden waaronder u reist.

Als u denkt aan de stilte in de trein als u reist voor Woon-werkverkeer, welke van onderstaande stellingen is dan het meest voor u van toepassing?

Stilte van de treinomgeving

- ○ Het is vaak lawaaierig in de trein
- ○ Het is vaak stil in de trein
- ○ Het is gedeeltelijk lawaaierig in de trein

Drukte

Als u denkt aan de drukte in de trein als u reist voor Woon-werkverkeer, welke van onderstaande stellingen is dan het meest voor u van toepassing?

- ○ Het is normaal gesproken druk in de trein tijdens de reis
- ○ Het is normaal gesproken niet druk in de trein tijdens de reis
- ○ Het is gedeeltelijk druk in de trein tijdens de reis

Een zitplaats vinden

Als u denkt aan het vinden van een zitplaats in de trein als u reist voor Woon-werkverkeer , welke van onderstaande stellingen is dan het meest voor u van toepassing?

- ○ Ik kan meestal zitten tijdens de reis.
- ○ Ik kan meestal niet zitten tijdens de reis.
- ○ Ik zit tijdens een deel van de reis
  (ik kan eerst geen zitplaats vinden, maar later wel)

Wat doet u meestal als u met de trein reist voor uw Woon-werkverkeer? Geef aan wat uw **belangrijkste** activiteit is (met andere woorden, waar u de meeste tijd aan besteedt)

Kies de **belangrijkste** activiteit uit de onderstaande lijst

Kies de **belangrijkste** activiteit uit de onderstaande lijst	Belangrijkste activiteit van huis naar bestemming	Belangrijkste activiteit van bestemming naar huis
Lezen	○	○
Praten	○	○
Ontspannen/dagdromen	○	○
Surfen op het internet	○	○
Social media	○	○
Luisteren naar muziek	○	○
Werken/studeren	○	○
Gamen	○	○
Slapen	○	○
Telefoneren	○	○
Anders, namelijk	○	○

We vragen u nu te denken aan één van uw Woon-werkverkeer treinreizen **van Bestemming naar huis** waarbij u zich bezighoudt met **Lezen**. Alle komende vragen vanaf nu gaan over deze reis en activiteit.

Wat voor soort apparatuur of andere spullen hebt u nodig om te kunnen Lezen? **U mag er meer dan één kiezen**

- [ ] Telefoon/iPad
- [ ] Laptop/pc
- [ ] Koptelefoon/iets om naar te luisteren
- [ ] Boek/krant/iets om te lezen
- [ ] Anders, namelijk
- [ ] Niets

Wilt u hieronder aangeven wat u verder nodig hebt om tijdens uw treinreis te Lezen. **U mag er meer dan één kiezen**

- [ ] Gewoon kunnen zitten
- [ ] Stoel met voldoende beenruimte
- [ ] Tafel
- [ ] Stopcontact
- [ ] Rustige omgeving
- [ ] Wifiverbinding
- [ ] Anders, namelijk
- [ ] Niets

Ervaart u Lezen als een **nuttige manier om uw tijd te besteden**?

- Ja, zeer nuttig
- Ja, nuttig
- Neutraal
- Nee, niet Nuttig
- Nee, helemaal niet nuttig

En ervaart u Lezen als een **aangename manier om uw tijd te besteden**?

- Ja, zeer aangenaam
- Ja, aangenaam
- Neutraal
- Nee, onaangenaam
- Nee, zeer onaangenaam

Hoeveel meer tijd hebt u nodig om te Lezen in de trein in vergelijking met de tijd die u nodig hebt op uw voorkeurslocatie?

- Veel meer tijd nodig in de trein
- Meer tijd nodig in de trein
- Zelfde tijd in de trein
- Minder tijd nodig in de trein
- Veel minder tijd nodig in de trein

Stelt u zich voor dat u zo'n soort reis **drie keer** kunt maken./ Tijdens de eerste reis besteedt u uw reistijd aan **Lezen**, / Tijdens de tweede reis besteedt u uw reistijd aan **nietsdoen** / tijdens de derde reis besteedt u uw reistijd aan **iets anders dan Lezen.**
Kunt u aangeven hoe waardevol uw reistijd is in elk van deze drie situaties?

Hoe waardevol is **de reistijd als u deze besteedt aan Lezen** tijdens het reizen?

1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

Laagste waarde — Hoogste waarde

Hoe waardevol **is de reistijd als u niets doet** tijdens het reizen? Geef een beoordeling van 1 tot 10

1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

Laagste waarde — Hoogste waarde

Hoe waardevol is **de reistijd als u deze besteedt aan iets anders dan Lezen** tijdens het reizen? Geef een beoordeling van 1 tot 10

1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

Laagste waarde — Hoogste waarde

SPEL: Keuze tussen reistijd en kosten

Welkom bij het keuze spel. In dit spel vragen we u om u voor te stellen dat u een treinreis maakt van station A naar station B. U heeft voor deze reis de keuze uit twee verschillende reismogelijkheden. De reismogelijkheden zijn in elk opzicht hetzelfde, behalve de reistijd en de kosten voor de reis: die verschillen tussen de twee reismogelijkheden. De tijdsbesteding tijdens de reis verschilt niet tussen de twee reismogelijkheden: u kunt voor beide reismogelijkheden WEL of NIET Lezen.

De reistijd van de reizen in dit onderzoek varieert per keuzeset, zodat zo veel mogelijk verschillende soorten reizen aan bod komen. We vragen u om steeds uw keuze te maken alsof u een reis maakt voor Woon-werkverkeer waar u graag zou willen Lezen.

We begrijpen dat het lastig kan zijn om keuzes te maken, maar vragen u toch om dit zo veel mogelijk te doen. Dat helpt ons om beter te begrijpen hoe uw keuzes veranderen onder verschillende omstandigheden.

Spel waarin u wel gebruik kunt maken van uw Boek/krant/iets om te lezen

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(1 van 6)

Uw reistijd in de trein bedraagt:	100 minuten	120 minuten
Uw reiskosten zijn:	€ 16,00	€ 8,00
Mogelijkheid om te Lezen	Ja, u heeft uw Boek/krant/iets om te lezen bij u.	Ja, u heeft uw Boek/krant/iets om te lezen bij u.
	●	●

Spel waarin u wel gebruik kunt maken van uw Boek/krant/iets om te lezen

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(2 van 6)

Uw reistijd in de trein bedraagt:	120 minuten	80 minuten
Uw reiskosten zijn:	€ 12,00	€ 16,00
Mogelijkheid om te Lezen	Ja, u heeft uw Boek/krant/iets om te lezen bij u.	Ja, u heeft uw Boek/krant/iets om te lezen bij u.
	●	●

Spel waarin u wel gebruik kunt maken van uw Boek/krant/iets om te lezen

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(3 van 6)

Uw reistijd in de trein bedraagt:	100 minuten	80 minuten
Uw reiskosten zijn:	€ 8,00	€ 16,00
Mogelijkheid om te Lezen	Ja, u heeft uw Boek/krant/iets om te lezen bij u.	Ja, u heeft uw Boek/krant/iets om te lezen bij u.
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(4 van 6)

Uw reistijd in de trein bedraagt:	30 minuten	20 minuten
Uw reiskosten zijn:	€ 3,00	€ 6,00
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u wel gebruik kunt maken van uw Boek/krant/iets om te lezen

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(5 van 6)

Uw reistijd in de trein bedraagt:	120 minuten	100 minuten
Uw reiskosten zijn:	€ 8,00	€ 12,00
Mogelijkheid om te Lezen	Ja, u heeft uw Boek/krant/iets om te lezen bij u.	Ja, u heeft uw Boek/krant/iets om te lezen bij u.
	●	●

Spel waarin u wel gebruik kunt maken van uw Boek/krant/iets om te lezen

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(6 van 6)

Uw reistijd in de trein bedraagt:	80 minuten	120 minuten
Uw reiskosten zijn:	€ 12,00	€ 8,00
Mogelijkheid om te Lezen	Ja, u heeft uw Boek/krant/iets om te lezen bij u.	Ja, u heeft uw Boek/krant/iets om te lezen bij u.
	●	●

U heeft nu het eerste spel afgerond. U gaat nu beginnen aan het tweede en laatste keuzespel. Let op dat hierbij de omstandigheden waaronder u reist zijn veranderd.

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(1 van 6)

Uw reistijd in de trein bedraagt:	20 minuten	30 minuten
Uw reiskosten zijn:	€ 6,00	€ 4,50
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(2 van 6)

Uw reistijd in de trein bedraagt:	20 minuten	10 minuten
Uw reiskosten zijn:	€ 3,00	€ 4,50
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(3 van 6)

Uw reistijd in de trein bedraagt:	10 minuten	30 minuten
Uw reiskosten zijn:	€ 4,50	€ 3,00
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(4 van 6)

Uw reistijd in de trein bedraagt:	30 minuten	20 minuten
Uw reiskosten zijn:	€ 3,00	€ 6,00
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(5 van 6)

Uw reistijd in de trein bedraagt:	30 minuten	10 minuten
Uw reiskosten zijn:	€ 4,50	€ 6,00
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

Spel waarin u uw Boek/krant/iets om te lezen bent vergeten

Mijn persoonlijke profiel:

Doel van mijn reis:	Woon-werkverkeer
Soort reis:	Bestemming naar huis
Favoriete tijdsbesteding:	Lezen
Benodigdheden:	Boek/krant/iets om te lezen

Maakt u een keuze tussen de hieronder aangegeven reisopties.

(6 van 6)

Uw reistijd in de trein bedraagt:	10 minuten	20 minuten
Uw reiskosten zijn:	€ 6,00	€ 3,00
Mogelijkheid om te Lezen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen	Nee, u heeft vergeten uw Boek/krant/iets om te lezen mee te nemen
	●	●

U bent nu bijna aan het einde van de vragenlijst gekomen. Er rest nog één vraag.
Kunt u aangeven wat uw gemiddelde jaarinkomen is ? Als referentie: het modaal inkomen bedraagt in 2017 ongeveer €37.000 bruto (en €27.000 netto).

- ○ Minder dan modaal
- ○ Ongeveer modaal
- ○ 1 tot 2 keer modaal
- ○ Meer dan 2 keer modaal
- ○ Weet niet / wil niet zeggen

Dit was het einde van de vragenlijst.We danken u hartelijk voor de tijd die u heeft genomen om dit aan dit onderzoek mee te werken. Wij zullen u via de NS Panel Nieuwsbrief te zijner tijd op de hoogte brengen van de resultaten van dit onderzoek.

Link to complete survey

https://www.cixos2.com/rss/E9216NS_NL/wave2/cgi-bin/ciwweb.pl?studyname=E9216NS_NLwave2&sessieuniek=VALUE&panelprofileid=VALUE&onduniek=VALUE

D: Other Results

Table appendix 0-1: Binary logit with interaction full model

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
ACT1	-0.271	0.309	-0.88	0.38	*	0.312	-0.87	0.39	*
ACT2	-0.137	0.102	-1.35	0.18	*	0.102	-1.34	0.18	*
ACT3	0.0504	0.123	0.41	0.68	*	0.124	0.41	0.68	*
AGE1	0.0153	0.134	0.11	0.91	*	0.133	0.12	0.91	*
AGE1_VA	0.117	0.288	0.41	0.69	*	0.289	0.4	0.69	*
AGE2	0.0858	0.157	0.55	0.58	*	0.159	0.54	0.59	*
AGE2_VA	-0.672	0.38	-1.77	0.08	*	0.407	-1.65	0.1	*
AGE3	-0.391	0.186	-2.1	0.04		0.197	-1.98	0.05	
AGE3_VA	0.7	0.51	1.37	0.17	*	0.546	1.28	0.2	*
BETA_TC	-0.311	0.0217	-14.35	0		0.0228	-13.63	0	
D_VOT	0.104	0.047	2.21	0.03		0.0493	2.11	0.04	
EDU1	-0.544	0.218	-2.5	0.01		0.221	-2.46	0.01	
EDU1_VA	-0.0715	0.386	-0.19	0.85	*	0.387	-0.18	0.85	*
EDU2	0.113	0.121	0.93	0.35	*	0.124	0.91	0.36	*
EDU2_VA	-0.315	0.226	-1.39	0.16	*	0.234	-1.35	0.18	*
EDU3	0.254	0.238	1.07	0.29	*	0.245	1.03	0.3	*
EDU3_VA	-0.351	0.427	-0.82	0.41	*	0.48	-0.73	0.47	*
GEN1	-0.113	0.158	-0.72	0.47	*	0.154	-0.74	0.46	*
GEN1_VA	0.315	0.384	0.82	0.41	*	0.385	0.82	0.41	*
GEN2	0.2	0.132	1.52	0.13	*	0.134	1.49	0.14	*
GEN2_VA	0.54	0.372	1.45	0.15	*	0.374	1.45	0.15	*
INC1	0.205	0.182	1.12	0.26	*	0.178	1.15	0.25	*
INC1_VA	-0.233	0.345	-0.67	0.5	*	0.328	-0.71	0.48	*
INC2	0.203	0.146	1.39	0.16	*	0.149	1.36	0.17	*
INC2_VA	0.102	0.269	0.38	0.7	*	0.277	0.37	0.71	*
INC3	0.766	0.279	2.75	0.01		0.287	2.67	0.01	
INC3_VA	0.565	0.49	1.15	0.25	*	0.539	1.05	0.29	*
INC4	0.109	0.175	0.62	0.53	*	0.181	0.6	0.55	*
INC4_VA	-0.389	0.358	-1.09	0.28	*	0.372	-1.04	0.3	*
TIC1	-0.328	0.149	-2.21	0.03		0.147	-2.24	0.03	
TIC1_VA	0.0336	0.288	0.12	0.91	*	0.294	0.11	0.91	*
TIC2	0.51	0.196	2.6	0.01		0.197	2.59	0.01	
TIC2_VA	0.047	0.251	0.19	0.85	*	0.255	0.18	0.85	*
TIC3	0.115	0.311	0.37	0.71	*	0.298	0.38	0.7	*
TIC3_VA	-0.233	0.576	-0.4	0.69	*	0.519	-0.45	0.65	*

TRA1	-0.164	0.156	-1.05	0.29	*	0.156	-1.05	0.29	*
TRA1_VA	-0.0494	0.347	-0.14	0.89	*	0.362	-0.14	0.89	*
TRA2	0.114	0.193	0.59	0.55	*	0.194	0.59	0.56	*
TRA2_VA	-0.468	0.297	-1.57	0.12	*	0.319	-1.47	0.14	*
TRA3	0.142	0.198	0.72	0.47	*	0.199	0.71	0.48	*
TRA3_VA	-0.383	0.322	-1.19	0.23	*	0.341	-1.12	0.26	*
TRI1	-0.121	0.115	-1.05	0.3	*	0.117	-1.03	0.3	*
TRI1_VA	-0.227	0.238	-0.95	0.34	*	0.254	-0.89	0.37	*
TRI2	-0.218	0.145	-1.51	0.13	*	0.146	-1.49	0.14	*
TRI2_VA	0.0289	0.286	0.1	0.92	*	0.306	0.09	0.92	*
VOT	0.142	0.0332	4.28	0		0.0333	4.28	0	
gamma	0.0796	0.0997	0.8	0.42	*	0.103	0.77	0.44	*

Table appendix 0-2: All interacted variables(VA =value of activities)

Factor Coeff.	Name
ACT1	Activity duration a quarter of trip
ACT2	Activity duration 3-quarter of trip
ACT3	Activity duration Full trip
AGE1	Age below 34
AGE1_VA	
AGE2	Age 55 and above
AGE2_VA	
AGE3	Age unknown
AGE3_VA	
BETA_TC	
D_VOT	
EDU1	Education level 1234
EDU1_VA	
EDU2	Education level 89
EDU2_VA	
EDU3	Education missing
EDU3_VA	
GEN1	Gender female
GEN1_VA	
GEN2	Gender unknown
GEN2_VA	
INC1	Income below average
INC1_VA	

INC2	1-2 times average
INC2_VA	
INC3	More than twice average
INC3_VA	
INC4	Don’t know/can’t tell
INC4_VA	
TIC1	Ticket payment full
TIC1_VA	
TIC2	Ticket payed by employer
TIC2_VA	
TIC3	Other
TIC3_VA	
TRA1	Transfer yes always
TRA1_VA	
TRA2	Transfer No usually not
TRA2_VA	
TRA3	Transfer never
TRA3_VA	
TRI1	Trip duration 0-35mins
TRI1_VA	
TRI2	Greater than 70mins
TRI2_VA	
VOT	Value of time
gamma	Scale parameter

Table appendix 0-3: Reference variables

Variable	Reference variable
Income	Average income
Ticket	Employer pays some part
Gender	Male
Transfer	Yes usually
Trip duration	36-70mins
Age	35-54
Activity duration	Half the trip
Education level	Level 567

Table appendix 0-4: Separate interaction models per activity

Commute reading(N=211, rho-sq=0.147)				
Name	**Value**	**Std err**	**t-test**	**p-value**
BETA_TC	-0.301	0.0282	-10.69	0
ΔVOT(€/hr)	4.362	0.0153	4.75	0
facEDU_low	-0.393	0.107	-3.66	0
fac_female	-0.302	0.0875	-3.45	0
facTIC_pay myself	-0.41	0.0699	-5.87	0
facTransfer always	-0.236	0.0674	-3.51	0
fac_trip duration(>70mins)	0.836	0.148	5.66	0
VOT(€/hr)	13.2	0.0123	17.96	0
gamma	0.167	0.124	1.34	0.18

Commute working(N=118 rho-sq=0.185)				
Name	**Value**	**Std err**	**t-test**	**p-value**
Fac_activity duration(3-quarter of trip)	-0.253	0.0774	-3.27	0
BETA_TC	-0.316	0.0359	-8.81	0
ΔVOT(€/hr)	6.54	0.026	4.21	0
facINC_High	0.537	0.142	3.79	0
facTIC payed by employer	0.486	0.114	4.27	0
fac_trip duration(>70mins)	-0.721	0.0965	-7.47	0
VOT(€/hr)	13.86	0.0222	10.41	0
gamma	-0.0898	0.158	-0.57	0.57

For those who read during their trip, education level, ticket, transfer and trip duration were found to have a significant effect on their VOTTS. Those with low education level (1-4) had about 40% lower VOTTS compared to those with higher education levels. Females also have about 30% lower VOTTS compared to males. The ticket payment also plays a role as those who pay themselves have a lower VOTTS. In terms of trip characteristics, those who always transfers had a lower VOTTS compared to the others while those with trip duration greater than 70mins have a higher VOTTS compared to smaller distances.

For commuters who work during their trip, income, ticket, trip duration and activity duration were found to have an effect on their VOTTS. Those who earn more than twice the average income have about 54% higher VOTTS compared to the other groups. Those whose ticket is payed fully by employers also have about 49% higher VOTTS compared to others. For trip duration, the VOTTS of commuters who work during the trip was found to be reduced by about 72% for those with duration longer than 70mins. Also, the activity duration reduces VOTTS by about 25% for commuters who work for about three-quarter of the total trip time. These effects of trip duration and activity duration on VOTTS indicate that activities could have an effect on VOTTS of those who work during their trip.

The separate interaction models for commuters who listen to music did not give any significant interaction probably because of the small number of respondents.

The findings from the seperate interaction models above indicate that working during a commute trip could lead to lower VOTTS. This is not the case for reading as the activity duration did not show significant effect with VOTTS. However, these findings cannot be compared to other research since segmentation by activity type is usually not done in previous VOTTS studies. Also, findings could be biased because of the way the survey is set-up since people were not assigned their actual trip duration. Nonetheless, it is worth exploring VOTTS by activity type and trip purpose. This could reveal interesting results regarding the effect of activities on VOTTS.

Table appendix 0-5: Distribution of survey respondents by context and distance class

Commute				
	Distance class			
Context	Short	Medium	Long	Total Respondents
with activity	118	86	180	384
without activity	116	160	108	384

Table appendix 0-6: Distribution of Survey respondents by context and distance class

Leisure				
	Distance class			
Context	Short	Medium	Long	Total Respondents
with activity	156	132	148	436
without activity	122	164	150	436

Table appendix 0-7: Choice tasks for short trips

Choice situation	tripa.time	tripa.cost	tripb.time	tripb.cost
1	20	6	30	4.5
2	20	3	10	4.5
3	10	4.5	30	3
4	30	3	20	6
5	30	4.5	10	6
6	10	6	20	3

SP without Activity1

	Trip A	Trip B
Time	20	30
Cost	6	4.5
ability to read	No You forgot your reading materials	No You forgot your reading materials

SP with Activity1

	Trip A	Trip B
Time	20	30
Cost	6	4.5
ability to read	Yes You have your reading materials	Yes You have your reading materials

Table appendix 0-8: Choice tasks for medium trips

Choice situation	tripa.time	tripa.cost	tripb.time	tripb.cost
1	50	6	35	10
2	65	6	35	8
3	50	10	65	6
4	35	10	65	8
5	35	8	50	6
6	65	8	50	10

SP without Activity1

	Trip A	Trip B
Time	50	35
Cost	6	10
ability to read	**No** You **forgot** your reading materials	**No** You **forgot** your reading materials

SP with Activity1

	Trip A	Trip B
Time	50	35
Cost	6	10
ability to read	**Yes** You have your reading materials	**Yes** You have your reading materials

Table appendix 0-9: Choice tasks for long trips

Choice situation	tripa.time	tripa.cost	tripb.time	tripb.cost
1	100	16	120	8
2	120	12	80	16
3	100	8	80	16
4	80	16	100	12
5	120	8	100	12
6	80	12	120	8

SP without Activity1

	Trip A	Trip B
Time	100	120
Cost	16	8
ability to read	**No** You **forgot** your reading materials	**No** You **forgot** your reading materials

SP with Activity1

	Trip A	Trip B
Time	100	120
Cost	16	8
ability to read	**Yes** You have your reading materials	**Yes** You have your reading materials