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New values for passenger travel and freight transport

Technical report | 21 November 2023

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Summary

Large transport infrastructure projects are often publicly-funded, long-term and expensive investments. In the Netherlands these projects are evaluated using cost-benefit analysis (CBA). The value of travel time (VTT) and value of travel time reliability (VTTR) are expressions of travel time preferences in monetary terms, and they are pivotal inputs for these analyses. Travel/transport time savings are commonly amount to the most important benefits in CBA. Therefore, accurate estimation of the VTT and VTTR is paramount to the evaluation of transport infrastructure projects.

Current national VTT(R) averages date back from 2013, when the last Dutch VTT study was executed. However, people's travel preferences can change. The objective of this study is to acquire new, updated national averaged values of travel preferences for passenger and freight transport in the Netherlands. The study is commissioned by KiM Netherlands Institute for Transport Policy Analysis. For passenger transport new values of travel time, reliability and comfort have been determined, including valuations for active transport modes such as cycling and walking. For freight transport new values of travel time (VTTF) and travel time reliability (VTTRF) have been found.

Methodology

The national averaged VTT and VTTR for passenger transport are derived from Stated Preference (SP) choice experiments. A questionnaire is distributed among a target audience, containing questions regarding trip characteristics, personal characteristics and several choice experiments. In the experiment, respondents are asked to choose between hypothetical alternatives, each describing a trip in terms of travel time, travel cost and possibly other characteristics. Respondents are asked each time which alternative is preferred. From these choices the value of travel time and travel time reliability can be inferred. For freight transport a cost-effective factor costs method has been adopted, leveraging data from earlier studies. The new factors cost data was collected in a separate project, the SP data was leveraged from the previous Dutch national VTT study.

The VTT and VTTR values are estimated by employing discrete choice models: models aiming to explain the observed choice made by the respondent in the experiment. Coefficients and interaction factors are added to these models to improve the model fit: boost the model's ability to explain the data. Once values have been obtained from these models, these number are applied to the sample of respondents to calculate their respective VTT/VTTR. Finally, these values are weighted to match statistics from the recent Dutch national travel survey.

Data collection (passenger transport)

For this national VTT study a new passenger travel survey was designed where more than 9,700 respondents participated. Roughly 80% of respondents were recruited from an internet panel and about 20% were recruited by an interviewer intercepting them during their travel. The survey contained 10 unique Stated Preference experiments, dedicated to various modes of transport (car, train, airplane and more) and valuations (value of travel time, reliability, comfort and more). Each respondent participated in two of them, based on their current travel activities. The choice experiments were dynamically constructed by a pivotal experimental design, so that each respondent received realistic choice tasks relatable to their current travel pattern.

The main data collection phase occurred in June and September 2022. Response rates for both the internet panel and intercept recruitment were high compared to previous studies, especially compared to the previous Dutch VTT survey from 2009/2011. The use of a high-quality internet panel and the increased rewards for participation in this new study are the likely cause for this improvement. A filtering procedure based on a list of predetermined conditions was applied to the respondent data. Conditions for exclusion were entries for which it was suspected that something had gone wrong during the survey, either because of a problem in the survey, a misunderstanding, or a mistake made by the respondent. About 80% of the observations remained for further analysis after this procedure. This procedure has resulted in a final dataset of more than 7.500 high-quality reliable responses.

Choice models

The VTT and VTTR is not identical for every person; it varies within the population. Personal and trip characteristics play a role as well. For example, people with higher incomes tend to have a higher VTT

compared to people with lower incomes. Our choice models need to account for this heterogeneity of preferences and characteristics. We have adopted Mixed Logit choice models, extended with a large set of interaction factors based on personal and trip characteristics, to accommodate for these variations. The lognormal shape of the VTT/VTTR distribution in the Mixed Logit was determined by a non-parametric analysis.

Our models have been developed along the linear Random Utility Maximisation (RU-LIN) framework. This is a common and well-founded framework in academic literature, although we are aware that the logarithmic Random Valuation (RV-LOG) framework has gained popularity in recent VTT studies. We conclude that the RU-LIN approach is more robust for this study since (1) it can be applied to all our experiments, (2) has a better theorical foundation in academic literature and (3) that the mean VTT and the heterogeneity of the VTT are fully identified separately. Sign/size effects of the time and cost differences were not included in the final model formulation. Rigorous evaluation revealed that the resulting VTT of a utility function with, versus without, the inclusion of sign- and size-effects rendered nearly identical results. We therefore opted for a more comprehendible model without including these effects.

Thereafter, the estimated Mixed Logit choice models are applied to the sample of respondents to calculate their personal VTT. The mean VTT over all respondents was calculated to obtain the national average VTT. Finally, weight factors were applied to these respondents to match the statistics of the study sample with the statistics of the recent Dutch national travel. The results presented in this summary are the average national values after matching to the national travel survey.

Results

This section summarises the results presented in this technical report of the Dutch national VTT study 2022. The results are structured in three sections:

1. VTT and VTTR results for passenger transport.
2. VTT multipliers route quality and crowding conditions (selected modes)
3. VTT time results for freight transport.

Results value of travel time and value of travel time reliability (passenger transport)

Table S1 shows the national VTTs for each combination of transport mode and travel purpose. The values are reported in euros at price level 2022 and include taxes. Generally, the VTT is highest for business trips and lowest for trips for other purposes. For commuters the highest VTT among (motorised) land modes is found for train and the lowest VTT is found for local public transport. For business and other purposes, the VTT is highest for car of all land modes. For the first time in a Dutch national VTT study values of travel time have been estimated for cycling, walking and access/egress modes from/to the airport. Cycling and walking VTTs are comparable to those of car, albeit for business travel purposes they are lower. Note that VTT levels for access/egress to/from the airport sit between regular land modes and air.

Also for the first time in a Dutch national VTT study, uncertainty bandwidths of the estimated national VTTs have been calculated.[1] The uncertainty bandwidths are designated in Table S1 by the values after "±" and are reported in euros at price level 2022. The uncertainty bandwidth is a construct of (1) the uncertainty in estimated model coefficients, (2) uncertainty from weight factors in the sample enumeration, (3) uncertainty from variation among persons in the sample enumeration population and (4) uncertainty from the demarcation of the population used in the sample enumeration. The bandwidth is established by the root-mean-square of these four elements. The uncertainty bandwidth depends on the number of respondents in the collected data, hence the uncertainty bandwidth for all purposes is narrower compared to individual travel purposes.

[1] Except for the VTT for airport access and egress trips.

Table S1 – Value of travel time, in € / hr (price level 2022, including taxes)

Value of travel time including uncertainty bandwidths				
	Purpose			
Mode	Commute	Business	Other	All purposes
Car	10.78 ± 0.63	21.20 ± 3.06	9.60 ± 0.40	10.42 ± 0.40
Train	12.05 ± 0.26	17.96 ± 1.75	8.64 ± 0.17	10.08 ± 0.12
Local public transport	7.62 ± 0.20	14.39 ± 2.59	6.66 ± 0.20	7.12 ± 0.12
All (motorised) land modes	10.76 ± 0.56	20.63 ± 2.37	9.34 ± 0.29	10.19 ± 0.33
Cycling	10.17 ± 0.28	11.20 ± 0.87	10.43 ± 0.30	10.39 ± 0.20
Walking	15.89 ± 0.41	14.72 ± 0.62	11.76 ± 0.17	11.84 ± 0.13
Recreational navigation	-	-	8.07 ± 0.07	8.07 ± 0.07
Air	-	110.22 ± 1.45	53.80 ± 3.18	61.79 ± 0.38
Value of travel time for airport access / egress				
	Purpose			
Mode	Commute	Business	Other	All purposes
Park & fly	-	31.49	13.90	15.57
Kiss & fly	-	18.59	11.12	11.86
Taxi	-	35.62	13.72	21.51
Train or train+bus	-	15.02	8.26	9.11
All modes	-	21.73	10.77	12.46

Table S2 displays the values for the reliability ratio (RR) and for the value of travel time reliability (VTTR) that were found in this study. The reliability ratio in the left column is an intuitive metric that can be calculated by taking the ratio of the VTTR over the VTT. The same interaction effects were applied to the VTT and VTTR in the choice models, so that the RR is consistent and can be applied to the national average VTT. The RR metric also allows for easier comparison to other studies.

Table S2 – Reliability ratio and Value of travel time reliability, in € / hr (price level 2022, including taxes)

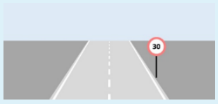
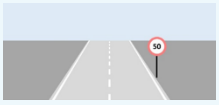
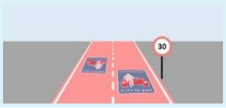
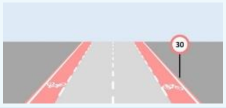
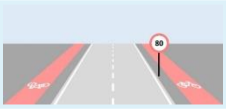
Mode	Reliability Ratio				Value of travel time reliability			
	Purpose				Purpose			
	Commute	Business	Other	All	Commute	Business	Other	All
Car	0.27	0.21	0.35	0.32	2.91	4.45	3.36	3.32
Train	0.32	0.11	0.27	0.27	3.86	1.98	2.33	2.76
Local public transport	0.65	0.61	0.56	0.59	4.95	8.78	3.73	4.17
Land modes (motorised)	0.30	0.21	0.35	0.33	3.18	4.38	3.28	3.31
Air	-	0.30	0.28	0.28	-	33.07	15.06	17.60
Recreational navigation	-	-	0	0	-	-	0.00	0.00

Results for VTT multipliers route quality and crowding conditions

Multipliers of selected transport modes have been estimated, so that route quality for walking/cycling and crowding condition in public transport can be correctly valued in cost-benefit analyses. The multipliers are calculated with respect to their average quality level obtained from the sample enumeration. A multiplier below 1 indicates that a route is more comfortable/convenient. This multiplier lowers the VTT. After all, if people like a certain route, there is less need for them to shorten the travel time. Or vice versa: if a route is very uncomfortable, people assign a higher value to a reduction of the travel time, which leads to a multiplier above 1. Multipliers for different quality aspects of the route may be multiplied with each other to get the total VTT multiplier for a route.

Table S3 shows the multipliers for the quality of walking and cycling routes that are most relevant for cost-benefit analyses. Other estimated multipliers such as car intensity, path width and pavement types can be found in Chapter 14. All multipliers have the expected size with respect to the other levels of the same attribute. Only the walking path multiplier for configuration 7 is lower than for configuration 8, which was not expected. It might be that pedestrians consider their walking path to be safer if more other people are present. It might also be a statistical coincidence, given the small difference in coefficients.

Table S3 – VTT multipliers for quality factors of cycling and walking routes

	Cycling path configuration		Walking path configuration	
	Description	**Multiplier**	**Description**	**Multiplier**
1	Car road – bikes allowed (30 km/h) 	1.085	Walking on road with cars and bikes (30 km/h) 	1.397
2	Car road – bikes allowed (50 km/h) 	1.233	Walking on road with cars and bikes (50 km/h) 	1.598
3	Bike street – cars allowed, bikes have priority (30 km/h) 	0.956	Sidewalk directly next to road with cars and bikes (30 km/h) 	1.100
4	Bike lane in the road (30 km/h) 	0.993	Sidewalk directly next to road with cars and bikes (50 km/h) 	1.192
5	Bike lane in the road (50 km/h) 	1.034	Sidewalk at 2 metres from road with cars and bikes (30 km/h) 	1.005
6	Bike lane next to the road (50 km/h) 	0.963	Sidewalk at 2 metres from road with cars and bikes (50 km/h) 	1.034
7	Bike lane next to the road (80 km/h) 	1.122	Shared bike/pedestrian path (no car traffic) 	0.818
8	Bike path (no other road around) 	0.862	Pedestrian path (no car traffic) 	0.832
	Type of pavement		**Walking path width**	
	Description	**Multiplier**	**Description**	**Multiplier**
1	Paving stones	1.183	Narrow path (less than 1 m) with obstacles (parked bikes, flower beds etc.)	1.072
2	Sidewalk tiles	1.169	Narrow path (less than 1m) without obstacles	1.008
3	Concrete slabs	1.085	Normal path (1 – 2m wide)	0.997
4	Asphalt	0.971	Wide path (more than 2m wide, boulevard-like)	0.952

Also multipliers for crowding conditions during public transport trips were. They are displayed in Figure S1. They are consistent with values found in other studies such as the UK and in Paris.

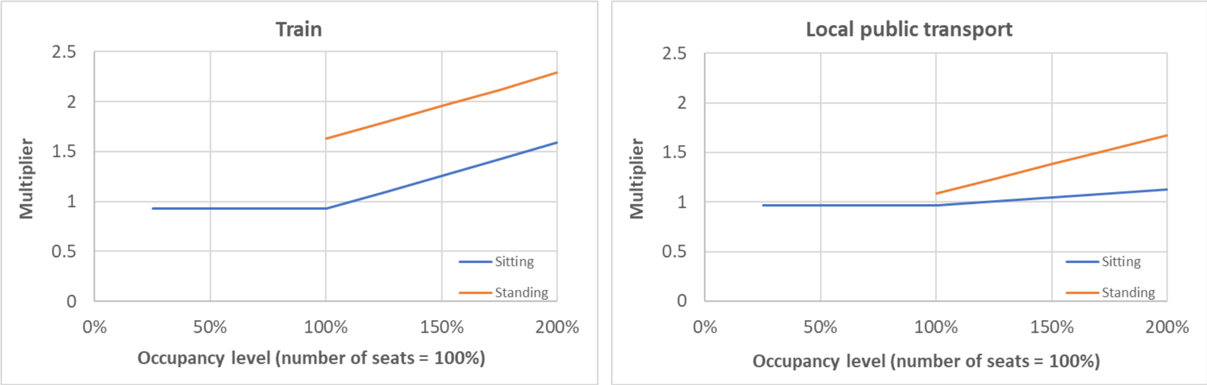


Figure S1 – (normalised) VTT multipliers for public transport crowding levels

During this study it was attempted to obtain multipliers for the different trip components of a public transport trip as well. We found access/egress time multiplier and wait/transfer time multiplier that were not significantly different from 1. These multipliers are low compared to similar multiplier values found in other studies. In contrast, the multipliers for the number of transfers found in our study is relatively high compared to the other sources. A critical review of the methodology has led us to conclude that the experiments might not have worked as wanted. Therefore, we recommend that the multipliers for access/egress time, wait/transfer time and number of transfers should not be used as official multipliers in the Netherlands.

Results value of travel time freight transport (VTTF)

In this study we developed a cost-effective method to produce representative VTTF (= value of transport time in freight transport) and VTTRF (= value of transport time reliability in freight transport) using new factor costs. This new factor cost data was collected in a separate project. The SP data was leveraged from the last Dutch national VTT study in 2009/2011. The VTTF and VTTRF values are reported in Table S4.

The freight time benefits of a transport project consist of the staff and vehicle time savings (together: the transport services component) and the cargo component. The former is calculated by taking all savings in transport costs except those for energy, tolls and rail access. For the first years after the start of a project we take a part of the full staff and vehicle time savings, from year 10 on we take the full staff and vehicle time benefits. For the cargo component we take 20% (containers) or 10% (non-container) of the long-run transport services component.

Table S4 - Recommended VTTF and VTTRF, in € / hr (price level 2022, including taxes)

	VTTF					VTTRF
	Transport services component		Cargo component	Total		Total (= cargo component)
	Long term	Year 1	Long term = Year 1	Long term	Year 1	Long term = Year 1
Road						
Container	53.0	53.0	10.6	63.6		
Non-container	57.3	57.3	5.7	63.1		
Average	56.8	56.8	6.3	63.1		23.3
Rail						
Container	843	270	169	1012	439	
Non-container	1107	355	110	1217	465	
Average	995	318	143	1137	461	204
Air						
Average	7702	4776	770	8472	5545	1016
Inland waterways						
Container- quay	141	18	28	169	46	
Container – lock/bridge	141	134	28	169	162	
Non-container - quay	158	21	16	174	37	
Non-container – lock/bridge	158	152	16	174	169	
Average - quay	155	21	18	173	39	60.5
Average – lock/bridge	155	148	18	173	167	15.6
Sea						
Container	1009	564	202	1211	767	
Non-container	953	533	95	1048	628	
Average	966	541	119	1084	660	130

Comparison to previous national VTT study

The VTTs obtained for passenger transport in this study are approximately 5-20% lower than was expected based on the results from the previous Dutch VTT 2009/2011 study (corrected for inflation and for 50% of the real income change). An extensive list of possible explanations has been explored on why the VTT from this study differs from the expected VTT based on the 2009/2011 study. Based on this exploration it can be concluded that the biggest contributions to the observed differences are likely to be given by:

- Change in general comfort levels and preferences.
- Self-selection effects in which travellers with relatively high VTTs switch to faster modes over time.
- Reduction in the number of transfers for local public transport users.
- Use of respondents recruited at intercept locations for the car VTT in the 2011-study.

- Uncertainty on how inflation should be included in this comparison.
- Uncertainty margins in the results.

For business travellers, the difference between VTTs obtained in this study versus the 2009/2011 study was more pronounced. Business VTTs are approximately 30%-40% lower in this study when corrected for inflation and 50% of the real income change. This can be attributed to a methodological change to the calculation of the employer component of the business trip. In the 2009/2011 study the Hensher method was adopted, while in this study the more renowned Willingness-to-Pay method was used. Analysis has shown that the methodological change amounts to 22%-32% relative difference so that without the methodological change business VTTs would follow the 10%-20% decrease found for other travel purposes.

The reliability ratios (RRs) found in this study are roughly 10-80% lower than found in the 2009/2011 study, especially for business trips made by car or by train. However, the new values are much more in line with reliability ratios found in the national studies in Norway 2018 (Flügel et al., 2020) Norway 2010 (Ramjerdi et al. 2010) and UK 2014 (Batley at al., 2019). It seems that the reliability ratios – and therefore VTTRs – found in the previous study were relatively high.

There are some clear differences between the methods on how the reliability ratios were determined in this study and in the previous study. The most relevant differences are:

- The presentation of the alternatives was different: in the 2022 study, no departure and arrival times were presented. Furthermore, the mean travel time of the five possible travel time was presented, whereas in the 2009/2011 experiment the most common (median) travel was shown.
- In the 2009/2011 study the average travel time was used in the modelling, while this was not explicitly presented to the respondents. It was assumed that the respondents had ignored the most common travel time and had calculated the average travel time from the of the five possible travel times. This may have led to confusion between the value of travel time and the value of travel time reliability.

Also the new results for freight the VTTF and VTTRF are substantially lower than values found in the previous freight VTT study. There are two important reasons for this divergence:

- The factor cost for most of the modes have decreased (2021 compared to 2009), in real terms and in nominal terms;
- Unlike in the previous study (Significance et al., 2013), in the current study we decided not to include the distance-dependent costs in the factor cost that are used for the calculation of the freight VTTs (and VTTRs).

The argument for the latter is that a change in transport time that is caused by a transport project should be related to the time-dependent transport costs only, which has been an internationally-agreed approach since 2013.

List of abbreviations

BRR	Boundary reliability ratio
BVTT	Boundary value of travel time
CBA	Cost-benefit analysis
CBS	"Centraal bureau voor de statistiek" (Statistic Netherlands)
CPI	Consumer price Index
EIB	European Investment Bank
EBRD	European Bank for Reconstruction and Development
EC	European Commission
HCG	Hague Consulting Group
HE	Hensher equation
KiM	"Kennisinstituut voor Mobiliteitsbeleid" (KiM Netherlands Institute for Transport Policy Analysis)
ODiN	"Onderweg in Nederland" (Dutch national travel survey from 2018)
OViN	"Onderzoek verplaatsingsgedrag in Nederland" (Dutch national travel survey, 2010-2017)
RP	Revealed preference
RR	Reliability ratio
SP	Stated preference
TAG	Transport appraisal guidance
UK	United Kingdom
VBTT	Value of business travel time
VTT	Value of travel time
VTTF	Value of travel time in freight transport
VTTR	Value of travel time reliability
VTTRF	Value of travel time reliability in freight transport
WTP	Willingness to Pay

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1. Introduction

1.1 Background

The value of travel time (VTT) is an expression of travel time preferences in monetary terms. It represents the trade-off between travel time and trip costs. It puts a price on what x minutes of travel time reduction is worth. The VTT is a pivotal input for cost-benefit analyses (CBA) for new national transport infrastructure projects and policies. Transport projects and policies are often large, long-term and publicly-funded investments; so meticulous assessment is required. A typical substantial economic benefit in national transportation infrastructure projects and policies are travel time improvements. They commonly amount to the largest share of benefits in CBA (Dubernet, 2019) and therefore significantly influence the outcome. Mackie et al. (2001) approximate the monetary benefits in the range of 60 – 80% of the total benefits. Hence accurate estimation of the VTT is of high societal relevance. Given the importance of VTT metrics in transport projects and policies, national VTT studies are regularly conducted (Abrantes & Wardman, 2011).

In the Netherlands, national VTT studies for passenger transport have been conducted in 1988 (reported in HCG 1990), 1997 (HCG 1998) and 2009/2011 (Significance et al. 2013). In the latter study, also VTT values for freight transport were determined. For other years, it was recommended to use the VTT from the most recent study and correct this for inflation and (in case of passenger transport) for 50% of the real income growth. However, this correction method does not take changes in the VTT due to changes in comfort or due to intrinsic changes in the preferences of travellers and transporters into account. Furthermore, the 50% correction for the real income growth is also uncertain. Therefore, a new national study is conducted approximately every 10 years. This also allows to incorporate the latest insights in how the VTT can best be determined into the national travel time valuation.

In 2019, the KiM Netherlands Institute for Transport Policy Analysis published a call for a new project to determine new VTT values for the Netherlands in 2020. A consortium led by the research agency Significance was awarded this project. Due to the Covid-19 pandemic the main data collection was postponed until 2022. The analysis of the data was finalised in 2023. This technical report contains a detailed description of the methodology, the survey, the analysis and the final results of this study.

1.2 Objective

The aim of this study is to determine the national averaged values of travel time and travel time reliability for passenger and freight transport. Additionally, also the value of travel time comfort for some passenger transport modes is to be measured.

For passenger transport, the values of travel time and travel time reliability is determined for the following modes: car (as a driver), train, local public transport (i.e. bus, tram and metro), recreational navigation and air. These modes were also studied in the 2009/2011 study. Additionally, in the current study, values of travel time and the value of route quality for walking and cycling should be obtained, and also comfort and convenience multipliers for public transport routes. Finally, since the values of travel time and travel time reliability for air only apply to the time in the airplane (rather than to the full door-to-door travel time), separate values of travel time for access trips to the airport and egress trips from the airport are computed for the following modes: car - park&fly, car – kiss&fly, public transport, taxi.

All values are specified separately for the same travel purposes as in the previous study: commute, business and other.

The figures for freight transport are determined based on a factor cost method and not with new SP experiments. They are studied for the same modes of transport as were examined in the previous study: road, rail, inland waterways, sea and air.

1.3 Project team

The consortium that carried out this project was led by Significance with Marco Kouwenhoven as the project leader, and Gerard de Jong, Sebastiaan Thoen, Jeroen Muller and Jasper Willigers as the main project team members.

Sander van Cranenburgh, assistant professor of choice modelling at Delft University of Technology, contributed to the design of the SP experiments, and the analysis of the choice data, and especially to the non-parametric analysis.

The survey fieldwork (both for the internet panel and for the on-site recruitment of respondents) was done by Kantar Public.

Three international experts (Richard Batley from the Institute for Transport Studies of the University of Leeds, UK; Maria Börjesson from the Center of Transport studies of the KTH Royal Institute of Technology in Stockholm, Sweden; and Askill Harkjerr Halse from Transportøkonomisk institutt in Oslo, Norway) advised the project team at certain milestones in the project based on their extensive experience in value of time studies from projects in their own countries. Five expert meetings were organised in which (1) the general methodology and the SP design, (2) the results from the pilot study, (3) the impact of the Covid-19 pandemic on the VTT in general, and on this survey specifically, (4) the general shape of the utility function, and (5) the (almost final) estimation results were discussed. Their inputs were used for the final decisions on these topics.

Kees van Ommeren, partner at Decisio and expert in the field of valuation of walking and cycling projects, advised on the design of the walk and cycle SP experiments and commented on the results from the pilot study and on the final results. His insights were used to further improve the design, modelling and understanding of the walk and cycle part of the survey.

2. Methodology

2.1 General

Direct inquiry of people's valuation of travel time is flawed. People often do not (fully) know why they made a choice or are hesitant to state their true reasons for their choices. There is a cognitive dissonance of judging/saying what one will do versus what one actually does/chooses. Choices speak louder than words. Consequently, using choice observation data is a more capable method to infer trade-off valuations such as the VTT. One can perceive a choice as a signal of underlying preferences (Samuelson 1948). There are two paradigms in the field of choice data collection: revealed preference (RP) and stated choice (SP). RP data are choices observed in real life situations, while SP experiments make respondents choose between hypothetical alternatives described by a set of attributes. An attribute is a characteristic of an alternative. In the context of VTT estimation travel time and travel costs are the most important attributes. Travel time reliability (variability), trip safety and trip quality/comfort are examples of other typical attributes that could describe an alternative. While real-world choices (RP) have well-documented advantages, one disadvantage is that it is often unknown from what set of alternatives a choice was made. In contrast, in a SP setting all alternatives are known and therefore allows the researcher to observe trade-offs between all alternatives, which is vital for inferring trade-off valuations. Another advantage of SP is that the researcher can ask a respondent to make a series of choices within a controlled experiment. In the context of VTT estimation RP experiments were more common in the 1960s and 1970s. However, since the 1980s the VTT has mainly been estimated through SP experiments and is now a renowned approach to understand travel behaviour (Louviere, Hensher, & Swait, 2000).

After choice data is collected, trade-off valuations as the VTT are determined through discrete choice models estimation. By definition, models are a simplification of real-world phenomena. Choice models aim to describe the real-world decision-making process of respondents as precise as possible. After the model is formulated, it is estimated on the data. Model estimation is the process of finding model parameters that fit/explain the choice data best. It is a search of what makes the data most likely. From these model parameters the VTT is derived. Reliably estimating VTTs is no small feat. For one, the VTT is not identical for every person or trip. People value travel time differently for alternative travel purposes or modes. Travel time for a commuting trip is valued differently from a leisure trip; travel time by car is valued differently from a trip by train. Demographics play a role too. To illustrate, people with higher income levels tend to have a higher VTT compared to people with lower incomes. Age, gender or household composition can influence the VTT as well.

So instead of a unified value, the VTT varies in the population. This variation (heterogeneity) means the VTT is distributed in the population. Understanding this VTT distribution is important for accurately specifying its mean, which is the objective of this study (Fosgerau 2006). If one is unable to determine the full range of the distribution, important information outside the range might be missing. In particular very high VTT values are prone to fall outside this range, but have the biggest influence on the mean VTT. Uncovering the full VTT distribution is therefore important to reliably estimate mean VTTs (Ojeda-Cabral, 2014).

Numerous VTT studies have been published in the last decades and the profession of VTT elicitation has evolved. Multiple design and model developments have been adopted in these studies: varying design strategies (Daly, Tsang, & Rohr, 2014; Ramjerdi et al., 2010), different model specifications (Fosgerau, 2007; Ojeda-Cabral, Batley, & Hess, 2016; Significance, 2013) and alternative experimental setups (Fosgerau, 2006; Hess et al., 2017; Significance, 2013). These developments have one thing in common: they are aimed towards better recovery of the VTT. In VTT elicitation, 'better' recovery is largely a matter of robustness. The analyst does not know the shape of the distribution or how respondents make choices *a priori*. So the robustness translates to the ability of a design to recover the true VTT.

2.2 Project phases

The project was set up with four main phases with some having additional sub phases, see Figure 1.

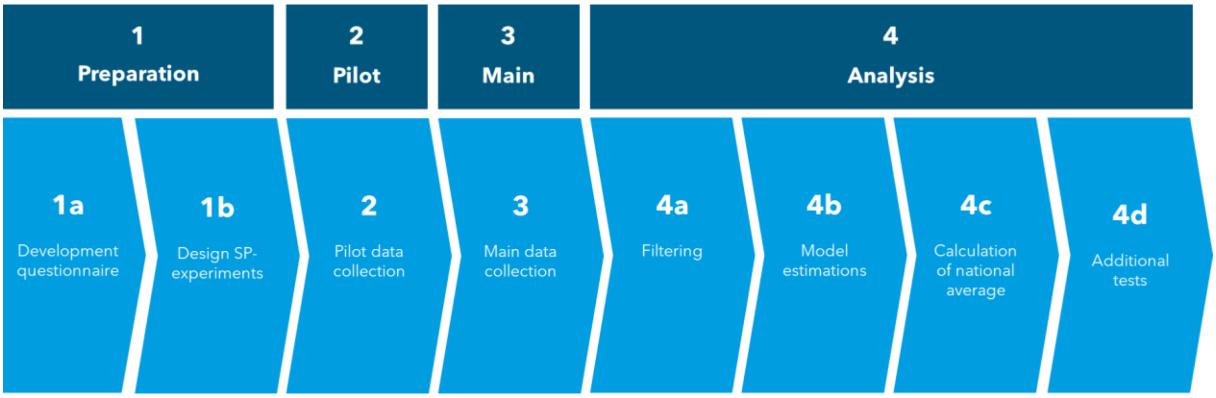


Figure 1 - Project phases

The project started in September 2019. In the first phase, the entire project was prepared. The detailed method for the determination of the freight values of transport time was developed. For the passenger survey, a questionnaire was developed which contained, in its final form, more than 500 questions (see Section 3.2 for more details). The survey included 10 different SP experiments which were designed in this initial phase (see Section 3.3). Finally, the web survey, containing the full questionnaire and all SP experiments, was programmed and tested.

By the end of February 2020, a pilot study was conducted with a limited number of respondents from an internet panel (Phase 2). The objective of this phase was to test the questionnaire and SP experiments in practice. In the following weeks, the results were analysed and a number of improvements were implemented into the web survey.

The main data collection phase (Phase 3) was planned for the Spring of 2020. However, due to the outbreak of the Covid-19 pandemic and the resulting lockdown, travel patterns were completely disturbed and the number of travel journeys drastically reduced. In order to obtain good and relevant results from the survey, it is paramount that it is conducted under normal travel conditions which were clearly not present during that period. Therefore, this phase was postponed several times awaiting a return to more or less normal travel conditions. For recreational navigation, the main fieldwork was done in the summer of 2021, but the fieldwork for all other travel modes had to wait until late Spring 2022 before the situation could be considered relatively normal. The final recruitment of respondents was done using two methods: recruitment using an internet panel and recruitment at intercept locations. The fieldwork was completed by the end of September 2022.

Next, the analysis phase (Phase 4) was started. For freight, the final calculations for the value of transport time were performed, and for passenger transport, the collected data was analysed. The data was cleaned by filtering respondents and observations based on pre-defined criteria. On the remaining data, choice models were estimated and the resulting coefficients were used to simulate the value of travel time for a large number of travellers such that a national average could be obtained. In the final subphase a large number of tests were performed to check the validity of the outcomes and to compare them with previous results.

2.3 Differences with the 2009/2011 study

In order to make a fair comparison of the VTT with the results of the 2009/2011 survey, the set-up of the 2022 study was as much as possible identical to the previous study. However, due to the experience with the previous survey, due to some other new theoretical insights, and due to practical reasons, the two surveys differed at several points.

One of the main differences is for freight transport. In the 2009/2011 study, freight carriers and freight shippers were interviewed and SP choice data was collected. However, due to difficulties to recruit these respondents, due to the limited ability to estimate good choice models from the obtained choice data, and due to the costs associated with the data collection and analysis, it was decided in advance of the 2022 study that no new SP data was to be collected and that new values of transport time were to be derived from a factor cost method (see Chapter 15 for full details).

Also for passenger transport the 2022 study differed from the 2009/2011 study at several points, such as details in the design of the SP experiments (Section 3.3), the type of internet panel used (Section 4.1), the number of respondents (Chapter 5) and the formulation of the utility function (Chapter 7). More details on these differences are given in the mentioned sections. In the discussion sections in Chapters 10 to 13, the impact of these differences will be described.

3. Survey

3.1 Eligibility

The following requirements were demanded from the respondents for them to be allowed to participate in this survey:

- they must be 16 years or older;
- they must be living in the Netherlands (excluding the Caribbean);
- they must speak/understand Dutch.

Respondents that were recruited via an internet panel were asked to describe a recent trip with the following conditions:

- the trip duration must be at least 10 minutes (all modes) and must be at most 24 hours (air only);
- the trip must have taken place in the last 4 weeks (car, train, local PT, cycling, walking) or in the last 3 months (air, recreational navigation);
- the trip must have been entirely within the Netherlands (except air);
- respondents that described a car trip must have been the car driver (rather than a car passenger) and must not have used public transport during the same trip;
- respondents that described a local public transport trip (i.e. bus, tram and/or metro) must not have used a train during the same trip;
- respondents that described a cycling or walking trip must not have made a round-trip with the purpose of just taking a walk or a bike ride without going to a certain destination. Furthermore, they must not have used another travel mode such as car or public transport during the same trip;
- respondents that described a recreational navigation trip must have passed at least one bridge or lock for which they had to wait before they could continue their trip.

Respondents were asked to confirm that their trip met the conditions described above. If not, they were asked to describe a different trip. If they did not make any recent eligible trip, they were excluded from the rest of the survey and thanked for their participation. Furthermore, the questionnaire contained questions which could be used to check whether both the trip and the respondent were eligible for the survey. If not, respondents were filtered out and were not used for the analysis (see Section 5.2).

Respondents that were recruited at intercept locations were later asked to describe the trip they made when they were invited for this survey. They were also asked to confirm that that trip met all conditions above (except the condition that the trip was made in the last 4 weeks / 3 months, which was self-evident). Also for these respondents trip eligibility was checked during the analysis phase.

3.2 Questionnaire

The full questionnaire contained roughly unique 500 questions, often tailored towards specific transport modes. Respondents typically answered only a fraction of those, which related to the respondents trip conditions. The structure of the questionnaire was as follows:

- Introduction message

  All respondents saw the following text:

  > *Deze vragenlijst gaat over reistijden en reiskosten en welke invloed deze hebben op uw reisgedrag.*

Dit onderzoek wordt gehouden voor het Kennisinstituut voor Mobiliteitsbeleid (onderdeel van het Ministerie van Infrastructuur en Waterstaat) en wordt gebruikt om infrastructuurmaatregelen te evalueren.

(translated into English: This questionnaire is about travel times and travel costs and what influence they have on your travel behaviour. This research is conducted for the KiM Netherlands Institute for Transport Policy Analysis (part of the Ministry of Infrastructure and Water Management) and is used to evaluate infrastructure measures.)

- Panel respondents were asked to think of the most recent eligible trip they made for a certain mode and purpose combination (see Section 4.1). Intercept respondents were asked to think of the trip they made when they were recruited for this survey. They were asked to confirm that that trip fulfilled all eligibility condition.
- Questions regarding origin and destination of the trip
- Questions on when the trip was made
- Questions on whether the trip was an outward or a return trip (or none of these). If it was an outward or return trip, the respondent was asked whether the same trip with the same mode but in opposite direction was made on the same day. A certain percentage of respondents were instructed to consider that trip in opposite direction for the rest of the questionnaire (in order to get a good mix of outward and return trips in the final sample).
- Questions on which modes were used during the trip (especially for public transport trips)
- Recreational navigation only: questions on the number of bridges / locks that were passed during the trip, how long they had to wait and how much it costed to pass
- Questions on how often this type of trip is made
- Public transport only: questions on the comfort level during the trip (e.g. crowding)
- Questions on departure time, arrival time, trip duration and delays
- Questions on (estimates of) trip distance
- Questions on trip cost
- Questions on activities at origin and destination location
- Questions on equipment and technologies available during the trip
- Questions on activities during the trip
- Cycling/walking only: questions on the quality of the route and the weather conditions during the trip
- SP experiment 1
- Questions on reliability of travel times (to make the respondents familiar with this topic)
- SP experiment 2
- Quality questions on the SP experiments
- Questions on the respondent’s characteristics (age, work situation, education level, income etc.)
- Thank you message

The full questionnaire (in Dutch) is available upon request.

3.3 Stated preference experiments

In total, the survey contained 10 SP experiments, each of which is related to one of the objectives of the study. Every respondent participated in two SP experiments. The type of experiment depended on the travel mode and in some cases also on some travel characteristics and a random draw. Table 1 provides an overview of the SP experiments including their objectives and which type of experiments were conducted for each travel mode. A detailed description of each experiment is given in the following subsections. The design of all SP experiments is discussed in Appendix A.

Table 1 – Overview of SP experiments

<table>
<tr><th>Travel mode</th><th>First experiment</th><th colspan="3">Second experiment</th></tr>
<tr><td>Car driver</td><td rowspan="3">SP1A
Value of travel time</td><td colspan="3">SP2A
Value of travel time reliability</td></tr>
<tr><td>Train
Local public transport
(bus, tram, metro)</td><td>SP2A
Value of travel time reliability</td><td>SP3A
Value of travel time comfort (trip components)</td><td>SP4A
Value of travel time comfort (crowding)</td></tr>
<tr><td>Air</td><td>SP2A
Value of travel time reliability</td><td>SP5A
Value of access travel time to an airport</td><td>SP6A
Value of egress travel time from an airport</td></tr>
<tr><td>Cycling
Walking</td><td>SP1B
Value of travel time</td><td colspan="3">SP2B
Value of travel time comfort</td></tr>
<tr><td>Recreational navigation</td><td>SP1C
Value of waiting time for bridge/lock</td><td colspan="3">SP2C
Value of reliability of waiting times for bridge/lock</td></tr>
</table>

3.3.1 SP1A – Value of travel time (car, train, local public transport, air)

The objective of this experiment is to determine the value of travel time. This experiment was presented to all respondents, except those who had walking, cycling or recreational navigation as their main mode. The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by two attributes: travel time and travel cost. See Figure 2 for an example.

Each participant in this experiment was presented with 8 choice situations. In all cases, one alternative was quicker and the other one was cheaper.

Rit A	Rit B
Reistijd: **45 min.**	Reistijd: **60 min.**
Kosten: **€ 7.80**	Kosten: **€ 5.10**

Figure 2 – Example of an SP1A choice card (in Dutch, see Appendix A for attribute names in English)

In each choice task there is an implicit price of time which is commonly referred to as the boundary value of travel time (BVTT). This BVTT is defined as:

$$BVTT = -\frac{C_1 - C_2}{T_1 - T_2} \qquad [1]$$

where C_1 is the cost of the first alternative ("Rit A" in the example above), etc. The BVTT can be perceived as a valuation threshold as a respondent choosing the fast and expensive alternative signals a VTT which is (most likely) above the BVTT, while a respondent choosing the slow and cheap alternative signals a VTT which is (most likely) below the BVTT.

3.3.2 SP1B – Value of travel time (cycling, walking)

The objective of this experiment is to determine the value of travel time for the travel modes cycling and walking. This experiment was presented to all respondents who had cycling or walking as their main mode.

Since the cost for walking and cycling trips are usually zero respondents were not presented with a route choice experiment, but got a hypothetical mode-choice experiment between their current mode and an alternative mode. This alternative mode was either car or electric rental bike. Respondents were asked which modes they could have used as an alternative mode. If more than one alternative mode was mentioned, they were asked which of those modes they preferred. If only "car" was selected, or "car" was the preferred alternative mode, this mode was used as the alternative mode.[2] Otherwise "electric bike" was used at the alternative mode. Intercept respondents always got electric rental bike as their alternative mode. If the respondent had cycling as their current mode, and if they already used an electric bike, they were instructed to assume that their electric bike was not available. This resulted in that they had to choose between a normal bike and an electric rental bike in the experiment.

Each alternative was described by two attributes: travel time and travel cost (see Figure 3 for an example). The travel time of the alternative mode (car or electric bike) was always lower than the travel time for the current mode (normal bike, or walking). The travel cost for the current mode was always zero, while the cost for car or the rental cost for the electric bike was always larger than zero.

Each participant in this experiment was presented with 8 choice situations.

Elektrische (huur)fiets	Fiets
Reistijd: **18 min.**	Reistijd: **25 min.**
Huurkosten: **€ 0.40**	Kosten: **€ 0.00**

Figure 3 – Example of an SP1B choice card (in Dutch, see Appendix A for attribute names in English)

3.3.3 SP1C – Value of waiting time for a bridge/lock (recreational navigation)

The objective of this experiment is to determine the value of waiting time for passing a lock or a bridge. This experiment was presented to all respondents who had recreational navigation as their main mode.

[2] In the pilot survey public transport was a possible alternative mode as well, but this was not included in the final survey since this alternative mode was only rarely selected by respondents, which made it impossible to use their data in the final modelling.

Note that we did not determine the value of travel time for these travellers, since people usually travel for recreational navigation for pleasure. Typically they prefer longer routes so that they can enjoy the trip more, implying a negative value of travel time.

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by two attributes: waiting time and cost for passing a lock or a bridge. See Figure 4 for an example.

Each participant in this experiment was presented with 8 choice situations.

Route A	Route B
Kosten per passage: **€ 2.00**	Kosten per passage: **€ 0.25**
Wachttijd voor brug/sluis: **15 min.**	Wachttijd voor brug/sluis: **45 min.**

Figure 4 – Example of an SP1C choice card (in Dutch, see Appendix A for attribute names in English)

3.3.4 SP2A – Value of travel time reliability (car, train, local public transport, air)

The objective of this experiment is to determine the value of travel time reliability. This experiment was presented to all respondents, except

- those who had walking, cycling or recreational navigation as their main mode;
- 38.5%[3] of the internet panel respondents who had public transport as their main mode (they had SP3A or SP4A as their second SP experiment);
- 55.6% of the internet panel respondents and 50.0% of the intercept respondents who had air as their main mode (they had SP5A or SP6A as their second SP experiment).

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by three attributes: travel cost, 5 possible travel times and the average travel time.

Each participant in this experiment was presented with 9 choice situations, see Figure 5 for an example. For one of these choices, one alternative was quicker, cheaper and more reliable (Figure 6). This choice was used as a check question (see Section 5.2). Four of the remaining 8 choice situations had the same travel cost for both alternatives, making it effectively a two-attribute choice.

Rit A	Rit B
Kosten: **€ 6.60**	Kosten: **€ 7.40**
U heeft een gelijke kans op elk van de volgende 5 reistijden: **54 min.** **58 min.** **60 min.** **1 uur en 2 min.** **1 uur en 6 min.**	U heeft een gelijke kans op elk van de volgende 5 reistijden: **32 min.** **45 min.** **55 min.** **1 uur en 5 min.** **1 uur en 18 min.**
Gemiddelde reistijd: **60 min.**	Gemiddelde reistijd: **55 min.**

Figure 5 – Example of an SP2A choice card (in Dutch, see Appendix A for attribute names in English)

[3] This percentage and those mentioned after the next bullet were set such that the total number of respondents in each experiment matched pre-defined targets.

Rit A	Rit B
Kosten: **€ 4.75**	Kosten: **€ 3.15**
Gemiddelde reistijd: **1 uur en 12 min.**	Gemiddelde reistijd: **56 min.**
U heeft een gelijke kans op elk van de volgende 5 reistijden: **56 min.** **1 uur en 5 min.** **1 uur en 10 min.** **1 uur en 19 min.** **1 uur en 31 min.**	U heeft een gelijke kans op elk van de volgende 5 reistijden: **51 min.** **54 min.** **55 min.** **58 min.** **1 uur en 2 min.**

Figure 6 – Example of an SP2A choice card with a dominant alternative (in Dutch): alternative B is cheaper, quicker and more reliable. Note that the order of the attributes is also randomised between respondents, (see Appendix A) which explains its difference compared to the previous example.

10% of the non-business respondents got a set of 8 choice questions (and a dominant question) based on the same underlying design that was used in the 2009/2011 study. The remaining 90% got 8 choice questions based on a new underlying design in which 4 choice pairs had a cost difference between the two alternatives and 4 choice pairs had equal costs for both alternatives, making them effectively a two-attribute sub-experiment within a three attribute experiment. For this type of questions, a boundary reliability ratios (BRR) can be defined similar to the boundary value of time in the SP1A experiment:

$$BRR = -\frac{T_1 - T_2}{\sigma_1 - \sigma_2} \quad [2]$$

in which σ_1 is the standard deviation of the five possible travel times as shown in alternative 1.

3.3.5 SP2B – Value of travel time comfort (cycling, walking)

The objective of this experiment is to determine the travel time multipliers for walking and cycling path comfort levels. This experiment was presented to all respondents who had walking or cycling as their main mode.

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by five attributes:

- travel time;
- cycling path configuration, or walking path configuration;
- type of pavement of the cycling path, or width of the walking path;
- amount of bypassing cars;
- beautifulness of the route.

A list of levels per attribute can be found in Appendix A.

Figure 7 shows an example choice situation. Each participant in this experiment was presented with 9 choice situations. One of these choices has a dominant alternative.

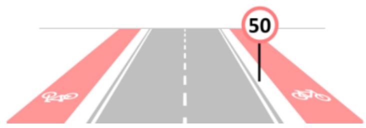
Rit A	Rit B
Route: **Zeer mooi**	Route: **Mooi**
Verharding: **Stoeptegels**	Verharding: **Stoeptegels**
Aantal voorbijrijdende auto's: **Zeer veel**	Aantal voorbijrijdende auto's: **Zeer weinig**
Reistijd: **28 min.**	Reistijd: **38 min.**
Fietspad: **Fietsstraat (auto's toegestaan, voorrang voor fietsers, 30 km/u)**	Fietspad: **Vrijliggend fietspad langs een weg (50 km/u)**
	

Figure 7 – Example of an SP2B choice card for cycling (in Dutch, see Appendix A for attribute names in English)

3.3.6 SP2C – Value of reliability of waiting times for bridge / lock (recreational navigation)

The objective of this experiment is to determine the value of waiting time reliability for passing a lock or a bridge. This experiment was presented to all respondents who had recreational navigation as their main mode.

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by three attributes: five possible waiting times, average waiting time and cost for passing a lock/bridge. See Figure 8 for an example.

Each participant in this experiment was presented with 9 choice situations. One of these choices has a dominant alternative.

Route A	Route B
Gemiddelde wachttijd voor brug/sluis: **30 min.**	Gemiddelde wachttijd voor brug/sluis: **10 min.**
U heeft een gelijke kans op elk van de volgende 5 wachttijden: **29 min.** **29 min.** **30 min.** **31 min.** **31 min.**	U heeft een gelijke kans op elk van de volgende 5 wachttijden: **1 min.** **4 min.** **10 min.** **16 min.** **25 min.**
Kosten per passage: **€ 0.25**	Kosten per passage: **€ 2.00**

Figure 8 – Example of an SP1C choice card (in Dutch, see Appendix A for attribute names in English)

3.3.7 SP3A – Value of travel time comfort (public transport trip components)

The objective of this experiment is to determine travel time multipliers for the components of a public transport trip.

A random draw determined whether a respondent internet panel respondents who had public transport as their main mode, was forwarded to either the reliability experiment SP2A (61.5%[4]), or to one of the experiments SP3A/4A (38.5%). In case of the latter, the following rules were applied to determine whether the respondent was assigned to the trip components experiment SP3A or the crowding experiment SP4A:

[4] This percentage was set such that the total number of respondents in each experiment matched pre-defined targets.

- If the recent public transport trip that they described, contained at least one transfer, they were forwarded to SP3A
- If the recent public transport trip had no transfers, and the trip was less than 30 minutes (train) or less than 20 minutes (local PT), they were forwarded to SP4A
- If the recent trip was a train trip, had no transfers, and was 30 minutes or longer, they had a 10% chance of being forwarded to SP3A and a 90% chance of being forwarded to SP4A.
- If the recent trip was a local public transport trip, had no transfers, and was 20 minutes or longer, they had a 50% chance of being forwarded to SP3A and a 50% chance of being forwarded to SP4A.

These rules are summarised in Table 2.

Table 2 – Assignment rules for SP3A/SP4A

Recent trip	Number of transfers	Duration	SP3A	SP4A
Train	0	< 30 minutes	-	100%
	0	30 minutes or more	10%	90%
	1 or more	(all)	100%	-
Local PT	0	< 20 minutes	-	100%
	0	20 minutes or more	50%	50%
	1 or more	(all)	100%	-

The SP3A experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by five attributes:

- in-vehicle travel time;
- access/egress travel time;
- total wait and transfer time;
- number of transfers;
- travel cost.

Figure 9 shows an example choice situation.

Each participant in this experiment was presented with 9 choice situations. One of these choices has a dominant alternative.

Treinreis A	Treinreis B
Reistijd in de trein : **42 min.**	Reistijd in de trein : **49 min.**
Reistijd van / naar de trein : **31 min.**	Reistijd van / naar de trein : **23 min.**
Totale wacht- en overstaptijd bij de trein : **3 min.**	Totale wacht- en overstaptijd bij de trein : **7 min.**
Aantal keer overstappen **2 overstappen**	Aantal keer overstappen **1 overstap**
Kosten: **€ 8.30**	Kosten: **€ 10.30**

Figure 9 – Example of an SP3A choice card (in Dutch, see Appendix A for attribute names in English)

3.3.8 SP4A – Value of travel time comfort (public transport crowding)

The objective of this experiment is to determine travel time multipliers for the level of crowding of a transport trip, and to determine the value of frequency for a public transport trip.

Some fraction of the respondents with public transport as their main mode, participated in this experiment. For a description of the assignment rules, see the SP3A description (Section 3.3.7).

The SP4A experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by five attributes:

- in-vehicle travel time;
- level of crowding;
- indicator whether you were able to sit, or whether you had to stand;
- frequency;
- travel cost.

A list of levels per attribute can be found in Appendix A. Figure 10 shows an example choice situation.

Each participant in this experiment was presented with 9 choice situations. One of these choices has a dominant alternative.

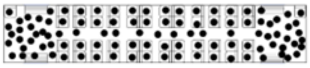
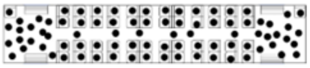
Treinreis A	Treinreis B
Reistijd in de trein : **40 min.**	Reistijd in de trein : **33 min.**
Drukte in de trein : **100% van de zitplaatsen bezet, er staan overal personen (3 personen per vierkante meter)** 	Drukte in de trein : **100% van de zitplaatsen bezet, er staan overal personen (2 personen per vierkante meter)** 
Zitten of staan? **U kunt zitten**	Zitten of staan? **U moet staan**
Frequentie **1 trein elke 60 minuten (1 per uur)**	Frequentie **1 trein elke 30 minuten (2 per uur)**
Kosten: **€ 7.20**	Kosten: **€ 14.20**

Figure 10 – Example of an SP4A choice card (in Dutch, see Appendix A for attribute names in English)

3.3.9 SP5A – Value of access travel time to an airport

The objective of this experiment is to determine the value of travel time for the access trip to the airport of an air traveller. Additionally, this experiment provides the value of additional time at the airport and the value of the probability of missing a flight.

This experiment was presented to:

- 44.4% of the internet panel respondents who had air as their main mode
- 50.0% of the intercept respondents who had air as their main mode

Respondents who had bus, metro or “other” as their only access mode to the airport never participated in SP5A and were forwarded to experiment SP2A instead.

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by six attributes:

- departure time;

- access travel time;
- expected arrival time at the airport;
- probability of missing your flight;
- additional time at the airport (compared to the latest possible arrival time at the airport, beyond which you are guaranteed to miss your flight);
- access travel cost.

Figure 11 shows an example choice situation.

Each participant in this experiment was presented with 9 choice situations. One of these choices has a dominant alternative.

Rit A naar de luchthaven	Rit B naar de luchthaven
Vertrektijd: **7:44**	Vertrektijd: **8:53**
Reistijd auto : **1 uur en 36 min.**	Reistijd auto : **57 min.**
Verwachte aankomsttijd op de luchthaven: **9:20**	Verwachte aankomsttijd op de luchthaven: **9:50**
Kans om uw vlucht te missen: **1 op de 1000 keer**	Kans om uw vlucht te missen: **1 op de 50 keer**
Extra tijd op de luchthaven: **2 uur en 0 min.**	Extra tijd op de luchthaven: **1 uur en 30 min.**
Reiskosten auto : **€ 9.50**	Reiskosten auto : **€ 11.00**

Figure 11 – Example of an SP5A choice card (in Dutch, see Appendix A for attribute names in English)

3.3.10 SP6A – Value of egress travel time from an airport

The objective of this experiment is to determine the value of travel time for the egress trip to the airport of an air traveller.

This experiment was presented to 11.1% of the internet panel respondents who had air as their main mode. Respondents who had bus, metro or "other" as their egress mode to the airport never participated in SP6A and were forwarded to experiment SP2A instead.

The experiment was presented as a route choice experiment, i.e. an hypothetical choice between two route alternatives (Trip A, Trip B), each described by two attributes: travel time and travel cost. The design and the presentation of the choice situation are identical to SP1A, see Figure 2 for an example.

Each participant in this experiment was presented with 9 choice situations. None of these choices had a dominant alternative.

3.4 Instructions

Before each SP, the experiment is introduced and a number of instructions are given. These instructions are specific for each experiment and each mode. To illustrate, car users travelling for non-business purpose get the following instructions prior to their first SP experiment:

- We are going to present two trips repeatedly, in which the travel times and costs are changed.
- Imagine that you can choose between two different routes.
  - the travel time can vary, for example, because one trip is shorter or less congested (and not because you accelerate more quickly),

  - the costs can vary, for example, because one trip requires less fuel.

  We ask you each time which trip you prefer.

- For each choice, assume the following:
  - both trips are feasible (even if they seem unrealistic),
  - you travel in your own time,
  - all costs are for your own account,
  - all other characteristics are equal for both trips (equally safe, equally pretty, parking costs are equal, etc.),
  - all other circumstances (the weather, your appointments and activities that day) are the same as during the journey which you have described.

In Appendix B, the full list of instructions for all experiments and for all type of respondents is specified.

4. Fieldwork

The fieldwork for this project consisted of both the recruitment of respondent and the collection of their answers to the questions in our questionnaire.

Recruitment was done using two methods:

- 7,704 respondents were recruited from an internet panel
- 1,832 respondents were recruited when they were intercepted during their trip

This large number of respondents does justice to the large variation among travellers in their trip and personal characteristics. It therefore allowed for an accurate determination of the national average VTT.

After travellers had agreed to participate, they were forwarded to an internet survey, which was the same survey for respondents recruited via the internet panel and via intercept (although some questions were asked in a slightly different way).

4.1 Recruitment using an internet panel

4.1.1 Internet panel

For this project we used the Kantar NipoBase internet panel. This is a high-quality research panel with a composition resembles the Dutch population composition according to the MOA Gold Standard. It is known for its large size (> 40,000 members) and its high response rate. Kantar guarantees the quality of its panel through their recruitment methodology and intensive panel management: new members are selected and approached by Kantar; respondents cannot register themselves.

4.1.2 Fieldwork period

For this study, respondents were recruited in five waves:

- Pilot survey (all modes, except recreational navigation): February 26th – March 9th, 2020: 606 respondents.
- Pilot recreational navigation: 4th – 16th October, 2020: 51 respondents.
- Main recruitment phase recreational navigation: August 19th – 25th, 2021: 157 respondents.
- Additional pilot air travellers (for experiments SP5A and SP6A): 5th – 9th May 2022: 49 respondents.
- Main recruitment phase (all modes, except recreational navigation): 14th June – 10th July, 2022: 6,841 respondents.

Each pilot survey was used to test the questionnaire and the SP experiments. After each pilot, it was checked whether the routing of the internet questionnaire was implemented correctly, whether all questions were clear and answered in a plausible way, and whether the SP experiments worked correctly. In the final analysis, it was decided to not use data from pilot respondents (see Section 5.2).

In a separate project, respondents from the pilot survey were re-approached in September 2020 for a similar survey that focused on changing behaviour and preferences as a result of the Covid-19 pandemic. In this study additional respondents were recruited. The outcomes of this study are reported in the report "Impact van corona op de reistijdwaardering" (Significance, 2021). Data from this project is not included in the study discussed in this report.

The main recruitment phase for recreational navigation was already completed at the end of the summer of 2021, despite the Covid-19 pandemic still being fully present in the societal fabric. An important consideration was that it was unclear when travel patterns would return to normal, and if this would align with a period of favourable weather condition for recreational navigation. Secondly, it was assessed that the impact of Covid-19 on this travel mode at that time could be neglected, given its strong dissimilarity to other modes.

4.1.3 Recruitment

The main recruitment phase for all other modes had a two-step approach. First, (almost) all members of the internet panel were asked to indicate the number of trips they made for each combination of travel mode and purpose over the last 4 weeks (or three months in case of an air trip). Based on these answers a stratified draw was made and a selection of the panel members were asked to participate in the survey, referring to a trip made with a certain (specified) mode and for a certain (specified) purpose. In the survey, they were asked to confirm that they indeed made such a trip recently. If not, they were allowed to complete the survey for another recent trip (i.e. other mode/purpose combination).

Targets were set for each main stratification segment (i.e. combination of mode and purpose) based on a minimum size (necessary to estimate significant coefficients) and proportionality with the size of this segment in the national travel survey ODiN 2019. Further stratification subsegments were defined based on age group and gender. Targets for these subsegments were set based on ODiN 2019.

Almost all targets were met, except the targets for the main stratification segments “local PT – business” and “air – business”, and some targets for the subsegments. We had some difficulties getting to the business targets in particular. The main reason for this was the decrease of the number of business trips that were made compared to 2019 (on which the targets were based). Reaching the targets for the segment for males with ages between 18 and 35 years also proved to be a challenge. We recruited a large number of respondents (more than 900), but the targets were even higher. According to KANTAR, this group of respondents is currently more difficult to convince to become a member in their internet panel.

4.1.4 Reward

Respondents who fully completed the survey received a reward equivalent to € 3.00. This was much higher than the reward of about € 1.50 (price level 2009) that was given to respondents of the 2009 survey and which low reward value was identified as one of the possible reasons why a relatively low value of travel time was found in that survey.

4.1.5 Response rate

For the second step of the main recruitment periods (i.e. after the draw), 12,753 panel members were invited, of which 8,551 started the survey. 1,553 of them did not complete the survey since they were not in scope (e.g. because the target for the sub segment to which they belonged was already fulfilled), or since they stopped prematurely, or since they were moved to another segment. In total 6,998 respondents completed the survey (which is 54.9% of all invited panel members, and 81.8% of those who started the survey). This response rate is much higher than the 13.0% response rate that was obtained in the 2009 survey which used a different (and lower quality) internet panel and which had lower rewards.

Table 3 provides a full overview of the response rates for each mode/purpose combination.

Table 3 – Response rate for the recruitment using the internet panel

Mode	Purpose	Invited	Started survey		Screen-out (not in scope)		Drop-out (stopped prematurely)		Redistribution (invited for other mode/purpose)		Completed	
Car	Commute	1217	862	*(70.8%)*	37	*(3.0%)*	75	*(6.2%)*	0	*(0.0%)*	750	*(61.6%)*
	Business	618	397	*(64.2%)*	5	*(0.8%)*	35	*(5.7%)*	0	*(0.0%)*	357	*(57.8%)*
	Other	1018	692	*(68.0%)*	40	*(3.9%)*	83	*(8.2%)*	2	*(0.2%)*	567	*(55.7%)*
Train	Commute	890	639	*(71.8%)*	7	*(0.8%)*	60	*(6.7%)*	8	*(0.9%)*	564	*(63.4%)*
	Business	406	261	*(64.3%)*	2	*(0.5%)*	18	*(4.4%)*	0	*(0.0%)*	241	*(59.4%)*
	Other	773	531	*(68.7%)*	20	*(2.6%)*	76	*(9.8%)*	17	*(2.2%)*	418	*(54.1%)*
Bus/tram / metro	Commute	906	579	*(63.9%)*	14	*(1.5%)*	71	*(7.8%)*	14	*(1.5%)*	480	*(53.0%)*
	Business	404	254	*(62.9%)*	4	*(1.0%)*	41	*(10.1%)*	17	*(4.2%)*	192	*(47.5%)*
	Other	1092	692	*(63.4%)*	30	*(2.7%)*	122	*(11.2%)*	31	*(2.8%)*	509	*(46.6%)*

Mode	Purpose	Invited	Started survey		Screen-out (not in scope)		Drop-out (stopped prematurely)		Redistribution (invited for other mode/purpose)		Completed	
Air	Business	699	500	*(71.5%)*	6	*(0.9%)*	63	*(9.0%)*	12	*(1.7%)*	419	*(59.9%)*
	Other	1443	1019	*(70.6%)*	10	*(0.7%)*	134	*(9.3%)*	22	*(1.5%)*	853	*(59.1%)*
Bicycle	Commute	535	339	*(63.4%)*	16	*(3.0%)*	27	*(5.0%)*	0	*(0.0%)*	296	*(55.3%)*
	Business	280	187	*(66.8%)*	6	*(2.1%)*	18	*(6.4%)*	2	*(0.7%)*	161	*(57.5%)*
	Other	567	368	*(64.9%)*	30	*(5.3%)*	38	*(6.7%)*	1	*(0.2%)*	299	*(52.7%)*
Walk	Commute	513	293	*(57.1%)*	7	*(1.4%)*	26	*(5.1%)*	16	*(3.1%)*	244	*(47.6%)*
	Business	341	201	*(58.9%)*	11	*(3.2%)*	25	*(7.3%)*	13	*(3.8%)*	152	*(44.6%)*
	Other	668	451	*(67.5%)*	29	*(4.3%)*	68	*(10.2%)*	15	*(2.2%)*	339	*(50.7%)*
Recr. nav.	Other	383	286*	*(74.7%)*	100	*(26.1%)*	29*	*(7.6%)*	0	*(0.0%)*	157	*(41.0%)*
All	All	12753	8551	*(67.1%)*	374	*(2.9%)*	1009	*(7.9%)*	170	*(1.3%)*	6998	*(54.9%)*

* For recreational navigation the number of dropouts were not recorded. The marked numbers were estimated afterwards based on the drop-out percentages of other modes.

4.2 Intercept

4.2.1 Recruitment and locations

Recruiters were strategically positioned at locations where a lot of travellers could be contacted, e.g. a petrol station/service area, parking garage, a bus stop or a train station. We primarily used locations that were also used in the 2011 survey (which used similar locations as the 1988 and 1997 surveys), but other locations were added to get a more representative set of locations (e.g. better geographical spread). A full list of the locations can be found in Table 4.

When a traveller is approached the recruiter briefly explained the goal of the survey and the reward, and asked whether he/she is willing to participate. If the traveller agreed to participate, the recruiter writes down the e-mail address of the participant. Within a few days the participant received an e-mail with a link to the survey. If the participant did not respond within a week, a second e-mail reminder was sent.

In total 3,991 respondents were recruited in this way. Note that no respondents were recruited via intercept for walking, since it was assessed that it would not be possible to find a location where this kind of respondents could be recruited in an effective way.

Table 4 – Intercept locations and number of recruited respodents

Mode	Intercept locations (in Dutch)	Num. Recruited	
Car	langs A2, parkeerplaats Het Haasje / Groote Bleek (nabij Maarheeze)	210	In 1988, 1997 and 2011 a nearby location was used
	langs A4, parkeerplaats Ruygenhoek Oost / West (nabij Nieuw Vennep)	147	Also used in 1988, 1997 and 2011
	langs A27, parkeerplaats 't Veentje (nabij Huizen)	147	New
	Amsterdam, parkeergarage Stadhuis / Muziektheater	36	Also used in 2011, in 1988 and 1997 a nearby location was used
	Amsterdam, parkeergarage Markenhoven	51	New
	Amsterdam, parkeergarage Weesperplein / Center East	41	New
	Den Haag, parkeergarage Plein, Rijnstraat of Prinses Irenestraat	73	Also used in 1988, 1997 and 2011
	Den Haag, parkeergarage Rijnstraat	28	Also used in 1988, 1997 and 2011
	Den Haag, parkeergarage Prinses Irenestraat	52	Also used in 1988, 1997 and 2011
	Den Haag, parkeergarage Museumkwartier	25	New
	Zwolle, parkeergarage centrum / Maagjesbolwerk	200	New
	Zwolle, parkeerplaats Burg. Van Royensingel / Karnebeekstraat	20	New
Train	treinstration Den Bosch	118	Also used in 1988, 1997 and 2011
	treinstation Den Haag Centraal	156	Also used in 1997, 2011
Local PT	busstation Amsterdam Centraal / halte Vijzelgracht	126	In 1988, 1997 and 2011 a nearby location was used
(bus/tram/metro)	bushalte Amsterdam Weesperplein	65	In 1997 and 2011 a nearby location was used
	busstation Arnhem Centraal	178	Also used in 1988, 1997, 2011
	busstation Den Haag Centraal / halte Oostinje	157	Also used in 1988, 1997, 2011
	busstation Den Bosch	144	In 2011 busstation Eindhoven was used
	busstation Utrecht Centraal Jaarbeurszijde	120	Also used in 2011
Air	vliegveld Rotterdam The Hague Airport	347	Also used in 2011
	vliegveld Schiphol	552	Also used in 2011
Cycling	fietsenkelder Utrecht Centraal Jaarbeurszijde	23	New
	snelfietspad langs A44 bij Laan van NOI / verkeerslichten N14	166	New
	fietspad tussen Gouda en Gouda Goverwelle	108	New
	Zwolle, kruising Katerdijk / Blaloweg	3	New
	Zwolle, fietsenstalling Gasthuisplein	138	New
	Zwolle, nabij Provinciehuis	12	New
	Utrecht, kruising Herculeslaan/Herculesplein	151	New
	Utrecht, fietsenstalling Neude	25	New
Recr. navigation	Sluis bij Muiden	230	Also used in 2011
	Haven Naarden	82	Also used in 2011
	Grevelingensluis (bij Bruinisse)	60	Also used in 2011
Total		3991	

4.2.2 Fieldwork period

- Car, train, bus/tram/metro, cycling: June 2022 and September 2022. No recruitment was done in July and August because of the summer holiday period, in which the traffic situation is not representative for the whole year.
- Air: June, July, August and September 2022. Recruitment continued over the summer holiday period since many air trips are made during this period, so including this period makes the full recruitment period more representative.
- Recreational navigation: August 2021. Many recreational navigation trips are made during the summer holiday period, so this is a representative period for conducting the survey.

4.2.3 Reward

Respondents who fully completed the survey received a reward equivalent to € 10,-. This was much higher than the expected value of the price draw in which the 2011 intercept respondents participated.[5] It was decided to give such a relatively high reward based on the experience of the 2011 survey when it turned out to be very difficult to motivate travellers to participate in that survey.

4.2.4 Response rate

3,991 respondents were invited to participate. More than 60% started the web-questionnaire. The remaining part either did not respond to the invitation, did not see the invitation (e.g. because the invitation mail arrived in their spam folder), or did not provide a correct e-mail address.

For the respondents who opened the questionnaire, some surveys were automatically stopped if the respondent was not eligible for the survey (4.5%). About 10% of the invited respondents started the survey but chose to stop it before it was completed. The total response rate based on completed interviews was 45.9% (ranging from 37.4% for recreational navigation to 51.5% for train). Some respondents that were recruited at a bus station turned out to make a trip that in our survey was defined as a train trip, so some re-segmentation took place afterwards.

Table 5 – Response rate for the intercept recruitment

Mode	Invited	Started survey		Screen-out (not in scope)		Drop-out (stopped prematurely)		Completed		Re-segment-ation	Final
Car	1030	659	*64.0%*	66	*6.4%*	72	*7.0%*	521	*50.6%*	-6	515
Train	274	190	*69.3%*	12	*4.4%*	37	*13.5%*	141	*51.5%*	125	266
Bus/tram/metro	790	477	*60.4%*	38	*4.8%*	111	*14.1%*	328	*41.5%*	-106	222
Air	899	492	*54.7%*	15	*1.7%*	95	*10.6%*	382	*42.5%*	0	382
Bicycle	626	404	*64.5%*	32	*5.1%*	51	*8.1%*	321	*51.3%*	-13	308
Recr. navigation	372	194*	*52.2%*	17*	*4.6%*	38*	*10.2%*	139	*37.4%*	0	139
All	3991	2416	*60.5%*	180	*4.5%*	404	*10.1%*	1832	*45.9%*	0	1832

* For recreational navigation, only the number of invited respondents and the number of completed surveys was recorded. The marked numbers were estimated afterwards based on the screen-out and drop-out percentages of other modes.

These response rates are an improvement over the rates that were obtained in the 2011-survey. Then 1757 respondents of the 3650 invited respondents started the survey (48.1%), 1430 completed the first SP experiment and were used in the analysis (39.2%). Only 1237 respondents completed all questions in the survey (33.9%). We believe that the improvement response rate in the current study is mainly due to the increased reward for a completed survey.

4.3 Survey duration

It took respondents about 15-20 minutes to complete the survey. Table 6 shows the survey duration (minimum, maximum, mean, median etc.) for each travel mode. As can be seen from this table, some respondents finished the survey in 3 or 4 minutes. Others took up to 9 hours to complete all questions, though it is likely that they took some break in between. Travellers using train or local public transport as their main mode had to answer more questions (especially on the description of the components of their trip) so that it took them on average a few minutes more to finish the survey. Respondents in the recreational navigation segment had the shortest questionnaire and hence the shortest survey duration.

[5] Two travel vouchers, each with a € 500 value were raffled among the 1,237 respondents, which gives an expected value for this price of € 0.81 (price level 2011).

Table 6 – Survey duration

		Mode						
		Car	Train	Local PT	Air	Cycling	Walking	Recr.nav.
Survey duration	minimum	5.1	4.4	4.4	3.4	5.5	4.0	3.5
(in minutes)	maximum	616.1	249.5	132.1	383.0	558.1	273.0	55.7
	10% percentile	9.8	11.2	10.5	9.1	9.6	8.9	7.1
	90% percentile	27.0	32.2	30.5	27.4	28.5	24.8	26.5
	median	15.3	17.6	17.1	15.1	15.9	14.4	13.2
	mean	17.5	20.6	19.2	17.5	18.2	16.5	15.5
	standard deviation	14.8	12.6	9.6	13.5	18.0	13.7	8.9

5. Respondents

5.1 Number of recruited respondents before filtering

As can be found in the previous chapter, 9,536 respondents completed the survey (7,704 respondents from the internet panel and 1,832 respondents recruited when intercepted during their trip). Table 7 shows the distribution of these respondents over all purpose/mode combinations. Most respondents were car drivers (more than 2,300). Train, local public transport and air modes had between 1,500 and 1,800 respondents. Cycling had roughly 1,150 respondents and walking had approximately 800 respondents. For recreational navigation, the smallest number of respondents were recruited (about 350).

Table 7 – Number of respondents that completed the survey

Recruitment type	Mode	Purpose			Total
		Commute	Business	Other	
Internet panel	Car	824	363	628	1815
	Train	599	250	513	1362
	Bus, tram, metro	505	194	573	1272
	Air	0	438	952	1390
	Cycling	327	162	355	844
	Walking	256	154	403	813
	Recr. navigation	0	0	208	208
Intercept	Car	111	178	226	515
	Train	90	32	144	266
	Bus, tram, metro	86	14	122	222
	Air	0	29	353	382
	Cycling	124	18	166	308
	Walking	0	0	0	0
	Recr. navigation	0	0	139	139
Total	Car	935	541	854	2330
	Train	689	282	657	1628
	Bus, tram, metro	591	208	695	1494
	Air	0*	467	1305	1772
	Cycling	451	180	521	1152
	Walking	256	154	403	813
	Recr. navigation	0	0	347	347
	Total	2922	1832	4782	9536

* One respondent travelling by plane has selected commute as travel purpose. This one respondent is too few to estimate a model, so we changed the purpose to "business" so that we did not have to exclude this respondent.

5.2 Filtering procedure

After the recruitment period was finished and all responses were collected, we analysed the quality of the answers. For this, we checked the surveys based on a list of predetermined conditions (i.e. set before the data collection started). These checks are compliant with typical checks made on choice experiment data and the checks that were done in the 2009/2011 survey.

The checks of the 2022 survey are organised in groups which are discussed below. An overview of the number of excluded respondents per criterion can be found in Table 8.

Pilots

- The pilot survey for car, train, local public transport and air was executed end February 2020, just before the outbreak of the Covid-19 pandemic in the Netherlands. The main survey was done more than two years later when most implications of the pandemic had faded. It is conceivable that travel behaviour and travel preferences have changed. Furthermore, the price level in 2020 was (very) different from the price level in 2022. For these reasons, it was decided that all 606 respondents from this pilot data should be excluded from the analysis phase.

- The additional pilot survey for air was intended to test the SP5A and SP6A experiments. This pilot demonstrated several problems with the routing and with the experiments. These problems were solved for the main survey. It was decided that the quality of the pilot data was not sufficient to be included in the analysis, so all 49 respondents were excluded.

Survey errors

- Check for errors in calculation of BaseTime (i.e. the travel duration of the recent trip). No errors were found.

- Check for errors in calculation of BaseCost (i.e. the travel cost of the recent trip). No errors were found.

- Check for errors in the routing of the questionnaire. No errors were found.

Missing data

- Check for missing data on base time. No problems were found.

- Check for missing data on base cost. For one respondent, the base cost level was missing. Since this information is crucial for the modelling stage, this respondent was excluded.

Not being eligible

- Travel time was less than 10 minutes. No occurrences were found.

- Travel time was more than 24 hours (mode = air only). 12 respondents were found whose trips were not eligible for this reason. 10 respondents were excluded (2 of the 12 respondents were already excluded for other reasons).

- Origin or destination was outside the Netherlands (all modes except air travel). Manual inspection of all specified origins and destinations revealed 30 respondents who specified an origin or a destination location that was clearly abroad.

- Public transport was used during the trip (current mode = car). At the beginning of the survey, a question was asked whether also train or local PT was used during the car trip. If so, the assignment to the car segment was automatically changed to a public transport segment. So, the questionnaire already prevented that car trips did not meet this criterion.

- Train was used during the trip (mode = local PT trip only). No internet panel-respondents were found ineligible based on this criterion. However, 19 out of the 222 intercept-respondents in this segment made a local PT-trip in which also a (smaller) part of the trip was made by train. This was not a mistake by the respondent, rather an erroneous assignment to the local PT segment in the survey. We have decided to include these respondents in the analysis.

- Car or public transport was used during the trip (mode = walk/cycling only). At the beginning of the survey, a question was asked whether also train or local PT was used during the car trip. If so, the assignment to the walk/cycling segment was automatically changed to a public transport segment. So, the questionnaire already prevented that car trips did not meet this criterion for the public transport part.

  The next question asked the (remaining) cycling/walking respondent to confirm that his/her trip met a list of conditions, among which was “You did not use any other mode during this journey (such as car or public transport)”. If the respondent did not confirm this, the questionnaire was stopped and the respondent was thanked for his/her cooperation.

- Number of locks/bridges was zero (mode = recreational navigation only). During the recruitment of intercept respondents we intentionally did not demand that there trip met this criterion. Due to a mistake in the survey for panel respondents, we could not check whether their trip met this criterion. So, no valid check on this criterion could be done.

- Origin and destination were the same. 12 respondents had both their origin and their destination defined as "huis" or "thuis" (i.e. "home"), indicating that they were thinking of a tour or a round-trip. This might have led to confusion; therefore these respondents have been excluded.

- Trip was not recent (trip was made more than four weeks ago (all modes except air / recreational navigation) / more than 3 months ago (mode = air / recreational navigation)). Note that this criterion is only relevant for panel respondents. When asked specifically when the most recent trip took place,

  - 106 air / recreational navigation respondents answered that is took place more than 3 months ago
  - 261 other respondents answered that it took place more than four weeks ago

  Both numbers are surprisingly high, since they have been asked to confirm at the beginning of the questionnaire that the most recent trip met a list of criteria, including that it took place in the last four weeks / three months. Nonetheless, these 367 respondents are excluded from the analysis (of which 26 were already excluded for other reasons).

- Respondent was younger than 16 years. One intercept respondent indicated that he/she was younger than 16 years. This respondent is excluded from the analysis.

- Respondent did not live in the Netherlands (excluding Caribbean) All intercept respondents and all panel respondents provided a valid Dutch zip code for their home location. Therefore, no respondents are excluded based on this criterion.

Inconsistencies

- Travel time without delay exceeds real travel time. No occurrences were found.

- Delay exceeds or is equal to travel time. If this is the case, the calculated free flow time becomes zero or negative. This implies that either the specified delay or the specified travel time is incorrect. 43 respondents were found whose trips were inconsistent based on this criterion of which 1 was already excluded for other reasons.

- Inconsistencies in the departure times and arrival times (mode = train, local public transport only). The respondents are asked to specify the departure time from home, the departure time from the first station / stop, the arrival time at the last station / stop and the arrival time at the final destination. These times should be in logical order. However, for 40 respondents that had SP3A as their second SP experiment, one or more times were mixed up. As a result, it was not possible to break the total travel time into trip components and it was decided to exclude these respondents (of which 15 were already excluded for other reasons).

Unrealistic / not plausible

- Travel time too large. The following BaseTimes were considered to be outliers (based on a combination of plausibility and observed distributions):

Car:	outlier if BaseTime > 240 minutes
Train:	outlier if BaseTime > 300 minutes
Local PT:	outlier if BaseTime > 240 minutes
Air:	outlier if BaseTime > 1440 minutes
Bicycle:	outlier if BaseTime > 90 minutes
Walk:	outlier if BaseTime > 180 minutes

  136 additional respondents were excluded based on this criterion.

- Travel cost too low or too high. The following BaseCosts were considered to be outliers:

Car:	outlier if BaseCost <= € 0.50 or BaseCost > € 60
Train:	outlier if BaseCost <= € 0.50 or BaseCost > € 75
Local PT:	outlier if BaseCost <= € 0.50 or BaseCost > € 50

Air: outlier if BaseCost <= € 0.50 or BaseCost > € 1250

106 additional respondents were excluded based on this criterion.

- Travel speed too high. The following speeds were considered to be outliers:

  Car: outlier if speed > 130 km/h
  Train: outlier if speed > 150 km/h
  Local PT: outlier if speed > 100 km/h
  Bicycle: outlier if speed > 35 km/h
  Walk: outlier if speed > 10 km/h

  60 additional respondents were excluded based on this criterion.

- Travel cost per hour too high. The following travel costs per hour were considered to be outliers:

  Car: outlier if BaseCost/BaseTime > € 30 / h
  Train: outlier if BaseCost/BaseTime > € 40 / h
  Local PT: outlier if BaseCost/BaseTime > € 30 / h
  Air: outlier if BaseCost/BaseTime > € 400 / h

  62 additional respondents were excluded based on this criterion.

- Number of transfers too large (public transport only). The following number of transfer were considered to be outliers:

  Train: outlier if number of transfers > 5
  Local PT: outlier if number of transfers > 5

  4 additional respondents were excluded based on this criterion.

- Number of locks/bridges too large (mode = recreational navigation only). The following number of locks/bridges were considered to be outliers:

  Recreational navigation : outlier if number of locks/bridges > 30

  5 additional respondents were excluded based on this criterion.

- Large difference between the real and expected travel time. The following delays were considered to be outliers:

  Car: outlier if delay > 90 minutes
  Train: outlier if delay > 90 minutes
  Local PT: outlier if delay > 60 minutes
  Air: outlier if delay > 120 minutes
  Bicycle: outlier if delay > 15 minutes
  Walk: outlier if delay > 10 minutes

  32 additional respondents were excluded based on this criterion.

Choice behaviour

- Lexicographic choice behaviour through both SP experiments (i.e. always chose the left-hand alternative, or always chose the right-hand alternative).

  If the first experiment was SP1B (cycling and walking), these answers were not considered for this criterion, since this was the mode choice experiment (rather than a route choice experiment) for which it is plausible that a respondent always chose the same mode. Therefore, it was only checked whether 8 times the left-hand alternative, or whether 8 times the right-hand alternative was chosen in experiment 2B

  If the second experiment was SP6A (i.e. the egress experiment for air travel, in which no dominant question was presented), it was checked whether 17 times the left-hand alternative, or whether 17 times the right-hand alternative was chosen in both experiments (SP1A and SP6A) together

In all other cases, it was checked whether 16 times the left-hand alternative, or 16 times the right-hand alternative was chosen.

33 additional respondents were excluded based on this criterion.

- Chose non-intuitive alternative of the dominant choice task. All respondents except those who had SP6A as their second experiment, were offered a dominant question (i.e. a choice task with a dominating alternative) as their last-but-one question.

  Overall, 4.8% of all respondents chose the dominated (i.e. the non-intuitive) answer. The experiment-specific percentages are 3.7% (SP2A), 1.9% (SP2B), 4.0% (SP2C), 13.6% (SP3A), 10.2% (SP4A), 8.4% (SP5A). 257 additional respondents were excluded based on this criterion.

Interview time

- Interview time unrealistically short. The respondents whose interview times fell within the first 1% percentile were considered to be outliers. Note that the number of questions varied strongly with the travel mode. Therefore, the 1% percentile was determined for each mode separately. 54 additional respondents were excluded based on this criterion.

- Time spent on the SP questions unrealistically short. The respondents whose times spent on the SP questions (both experiments together) fell within the first 1% percentile were considered to be outliers. Note that the complexity of the SP questions varied between experiments. Therefore, the 1% percentile was determined for each combination of SP experiments separately. 26 additional respondents were excluded based on this criterion.

In total, 1892 unique respondents were excluded, see Table 8. This list of exclusions applies to the SP1A/B/C experiments and to the SP2A/B/C and SP3A/4A experiments. However, 27 air respondents who participated in SP5A or SP6A were excluded based on one or more of the "Unrealistic / not plausible" checks. These deviating BaseTimes and/or BaseCosts did not affect the SP5A/6A experiments. Therefore, it was decided to only exclude them from SP1A, but still include them for the analysis of SP5A/6A.

Table 8 – Overview of excluded respondents. The column Occurrence presents the number of respondents that matched the exclusion criterion. The column Unique presents the number of respondents that matched the exclusion criterion and were not excluded for any of the previous criteria.

	Exclusion criterion	Occurrence	Unique
Pilots	Pilot survey (winter 2020, pre-corona)	606	606
	Additional pilot air travellers (spring 2022)	49	49
Missing crucial data	Missing data for BaseCost	1	1
Not eligible	Travel time was more than 24 hours (air only)	12	10
	Origin or destination was outside the Netherlands (all modes except air travel)	30	30
	Origin and destination were the same	12	12
	Trip was not recent	367	341
	Respondent was younger than 16 years	1	1
Inconsistencies	Delay exceeds or is equal to travel time	43	42
	Inconsistencies in departure, stop and arrival times for PT	40	25
Unrealistic / not plausible	Travel time too large	204	136
	Travel cost too high	137	106
	Travel speed too high	72	60
	Travel cost per hour too high	109	62
	Number of transfers too large (mode = public transport only)	7	4
	Number of locks/bridges too large (mode = recreational navigation only)	5	5
	Big difference between the travel times with and without delay	65	32
Choice behaviour	Lexicographic choice behaviour through both SP experiments	49	33
	Chose non-intuitive alternative of the dominant choice pair	454	257
Interview time	Interview time unrealistically short	92	54
	Time spent on the SP questions unrealistically short	92	26
Total			1892

5.3 Number of respondents for the analysis after filtering

7,644 respondents remained after filtering and were used in the analysis of the survey.[6] Table 9 shows the distribution of these respondents over the purpose/mode combinations. On average, 80.2% of the respondents remained, varying from 64.1% (internet panel, train/other) to 96.4% (intercept, recreational navigation/other), as can be seen from Table 10.

[6] This number applies to the number of respondents used in SP1A/B/C. As discussed in the previous section, 27 additional air respondents are used for the analysis of SP5A/6A.

Table 9 – Number of respondents that remained after filtering

Recruitment type	Mode	Purpose			Total
		Commute	Business	Other	
Internet panel	Car	670	323	500	1493
	Train	508	187	329	1024
	Bus, tram, metro	424	161	421	1006
	Air	0	317	724	1041
	Cycling	277	141	247	665
	Walking	197	124	284	605
	Recr. navigation	0	0	166	166
Intercept	Car	103	164	192	459
	Train	79	25	135	239
	Bus, tram, metro	78	11	105	194
	Air	0	23	306	329
	Cycling	117	16	156	289
	Walking	0	0	0	0
	Recr. navigation	0	0	134	134
Total	Car	773	487	692	1952
	Train	587	212	464	1263
	Bus, tram, metro	502	172	526	1200
	Air	0	340	1030	1370
	Cycling	394	157	403	954
	Walking	197	124	284	605
	Recr. navigation	0	0	300	300
	Total	2453	1492	3699	7644

Table 10 – Percentage of respondents that remained after filtering

Recruitment type	Mode	Purpose			Total
		Commute	Business	Other	
Internet panel	Car	81.3%	89.0%	79.6%	82.3%
	Train	84.8%	74.8%	64.1%	75.2%
	Bus, tram, metro	84.0%	83.0%	73.5%	79.1%
	Air		72.4%	76.1%	74.9%
	Cycling	84.7%	87.0%	69.6%	78.8%
	Walking	77.0%	80.5%	70.5%	74.4%
	Recr. navigation			79.8%	79.8%
Intercept	Car	92.8%	92.1%	85.0%	89.1%
	Train	87.8%	78.1%	93.8%	89.8%
	Bus, tram, metro	90.7%	78.6%	86.1%	87.4%
	Air		79.3%	86.7%	86.1%
	Cycling	94.4%	88.9%	94.0%	93.8%
	Walking				
	Recr. navigation			96.4%	96.4%
Total	Car	82.7%	90.0%	81.0%	83.8%
	Train	85.2%	75.2%	70.6%	77.6%
	Bus, tram, metro	84.9%	82.7%	75.7%	80.3%
	Air		72.8%	78.9%	77.3%
	Cycling	87.4%	87.2%	77.4%	82.8%
	Walking	77.0%	80.5%	70.5%	74.4%
	Recr. navigation			86.5%	86.5%
	Total	83.9%	81.4%	77.4%	80.2%

5.4 Person characteristics of sample after filtering

Table 11 shows the characteristics per mode of the final sample of 7,644 respondents that are used for the estimations.

- Recreational navigation has the highest percentage of male respondents (61.8%), while local public transport has the highest percentage of female respondents (59.9%);
- Train respondents are on average the youngest (41.4 years), recreational navigation respondents are the oldest (54.3 years), with a large gap to the mode with the oldest-but-one respondents (walking, 48.7 years);
- Air passengers have the highest percentage of high-educated respondents (62.2%), while local public transport have the lowest percentage (48.3%);
- Car drivers have the highest percentage of employed respondents (84.0%), while local public transport users have the lowest percentage (65.9%);
- Air respondents have on average the highest household income (€ 78,600 per year, before taxes), closely followed by recreational navigation respondents (€ 77,900). Local public transport respondents have on average the lowest household income (€ 61,200), closely followed by walkers (€ 61,600) and cyclists (€ 62,200).

Note that these numbers apply to the unweighted sample of respondents. For the final calculation of the national average value of travel time, respondents will be weighted such that their distribution matches that of the national travel survey.

Table 11 – Characteristics of the persons in the sample

Characteristic		Mode						
		Car	Train	Local PT	Air	Cycling	Walking	Recr.nav.
Gender	Male	61.8%	45.4%	40.1%	50.7%	50.2%	41.7%	63.7%
	Female	38.2%	54.6%	59.9%	49.3%	49.8%	58.3%	36.3%
	Other / don't say	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
Age category	35 years or younger	25.6%	43.2%	41.0%	31.0%	28.5%	26.9%	11.7%
	36 -50 years	33.1%	26.4%	22.2%	31.7%	25.3%	27.6%	26.3%
	51 - 65 years	32.3%	22.8%	24.7%	30.4%	32.0%	29.8%	38.7%
	66 years or older	9.0%	7.7%	12.2%	6.9%	14.3%	15.7%	23.3%
Average age		47.3	41.4	43.6	45.1	48.0	48.7	54.3
Education	LO/MAVO/VBO/ VMBO/LBO	10.7%	9.1%	15.6%	8.2%	11.8%	10.4%	10.0%
	MBO	26.5%	13.1%	19.0%	17.6%	19.4%	23.6%	24.3%
	HAVO/VWO	11.9%	16.1%	16.3%	10.9%	13.4%	14.2%	11.0%
	HBO/WO	50.2%	60.6%	48.3%	62.2%	53.9%	51.2%	53.0%
	Other / unknown	0.8%	1.1%	0.9%	1.2%	1.5%	0.5%	1.7%
Work situation	Employed	84.0%	71.7%	65.9%	82.6%	72.1%	71.9%	67.0%
	Unemployed	5.9%	5.4%	10.2%	5.3%	6.9%	14.2%	8.3%
	Student	1.7%	15.4%	13.8%	4.6%	6.9%	2.0%	2.3%
	Retired	7.7%	6.3%	9.0%	6.4%	13.1%	10.4%	21.3%
	Other / unknown	0.7%	1.3%	1.2%	1.2%	0.9%	1.5%	1.0%
Income	16,000 or less	2.3%	6.1%	6.7%	3.0%	5.0%	4.3%	2.3%
(yearly	16,001 – 22,400	2.2%	2.7%	3.7%	2.3%	3.2%	3.6%	3.3%
household inc.	22,401 – 29,500	3.7%	4.3%	4.6%	2.8%	4.5%	6.0%	2.7%
before taxes	29,501 – 36,500	5.6%	5.8%	6.3%	4.2%	6.1%	8.8%	6.3%
in euro)	36,501 – 43,500	7.6%	7.0%	7.6%	6.3%	8.3%	6.8%	5.7%
	43,501 – 57,600	16.1%	13.1%	12.7%	12.6%	14.3%	15.2%	10.3%
	57,601 – 73,000	12.3%	12.4%	13.4%	12.4%	11.8%	11.2%	15.0%
	73,001 – 87,100	10.1%	7.5%	6.1%	10.3%	8.3%	7.4%	8.0%
	87,101 – 116,500	12.7%	13.1%	10.2%	13.7%	10.6%	10.2%	9.0%
	116,501 – 174,200	6.9%	6.8%	5.8%	10.6%	4.2%	4.0%	8.3%
	174,201 or higher	2.6%	2.2%	0.8%	3.0%	1.2%	1.7%	4.3%
	Unknown / don't say	18.1%	18.9%	22.4%	18.8%	22.5%	20.8%	24.7%
Ave. income	(estimated)	71600	68200	61200	78600	62200	61600	77900

5.5 Trip characteristics of the sample after filtering

Table 12 shows the BaseTime and BaseCost characteristics per mode of the final sample of 7,644 recent trips described by the respondents.

- Average (in-airplane) travel time for air respondents is just over 4 hours, which is obviously the longest. On average, the shortest trips are made by cyclists (26.9 minutes);
- Average travel cost for air respondents is (obviously) the highest with almost € 235, while a local public transport trip is on average cheapest (€ 5.18).

Table 12 – Characteristics of the trips in the sample

Characteristic		Mode						
		Car	Train	Local PT	Air	Cycling	Walking	Recr.nav.
BaseTime	minimum	10.0	12.0	10.0	25.0	15.0	15.0	n.a.
(in minutes)	maximum	240.0	300.0	240.0	1435.0	90.0	180.0	n.a.
	median	45.0	79.0	50.0	180.0	20.0	25.0	n.a.
	mean	56.5	89.2	54.8	242.4	26.9	34.8	n.a.
	standard deviation	43.6	45.3	30.8	206.1	15.4	29.9	n.a.
BaseCost	minimum	€ 0.55	€ 1.00	€ 0.65	€ 1.00	€ 0.00	€ 0.00	n.a.
(in euro)	maximum	€ 60.00	€ 69.90	€ 47.50	€ 1,250.00	€ 0.00	€ 0.00	n.a.
	median	€ 6.00	€ 11.00	€ 3.45	€ 159.75	€ 0.00	€ 0.00	n.a.
	mean	€ 8.89	€ 13.57	€ 5.18	€ 234.58	€ 0.00	€ 0.00	n.a.
	standard deviation	€ 8.99	€ 10.15	€ 5.51	€ 206.49	€ 0.00	€ 0.00	n.a.

5.6 SP data characteristics of sample after filtering

Table 13 shows the trading percentages for the first SP experiment (i.e. the time versus cost experiment). For all modes except cycling and walking, between 91.3% and 96.7% of the respondents sometimes chose the cheapest/slowest alternative and sometimes chose the quickest/most expensive alternative in their series of 8 choices. Only between 0.8% and 1.9% always chose the quickest/most expensive alternative. This is important, since for these respondents their choices do not provide an indication for their internal value of travel time. Previous studies have encountered problems recovering the VTT distribution within the population if this percentage was too high. But in this study, this percentage is low enough that we can be sure that we can fully recover the VTT distribution, as will be shown in the next chapter.

The cycling and walking experiments were mode choice experiments rather than route choice. This implies that the alternatives not only differed in terms of time and cost, but also on mode. So, mode preferences may also have played a role in the choice and that is why the percentage of trading is much lower in these experiments. However, based on previous experience, a trading percentage between 50% and 60% is sufficient for good models to be developed.

Table 13 – Trading percentages for the SP1A/B/C experiment by mode

Characteristic		Mode						
		Car	Train	Local PT	Air	Cycling	Walking	Recr.nav.
SP1A/B/C	Always cheapest / slowest	6.2%	3.6%	6.4%	2.2%	37.9%	42.1%	7.3%
	Trading between slowest and quickest	91.9%	95.1%	92.8%	96.7%	56.3%	56.5%	91.3%
	Always quickest / most expensive	1.9%	1.3%	0.8%	1.1%	5.8%	1.3%	1.3%

6. Non-parametric analysis

6.1 Background

As briefly discussed in Chapter 2 the VTT varies among people and therefore has a certain distribution in the population. Accurate recovery of the shape of this VTT distribution is crucial for determining the mean VTT (which is the most commonly used metric in CBA). In particular the fatness of the tail of the distribution is important. A slightly fatter (or slimmer) tail results in a relatively large increase (or decrease) in the mean VTT. In fact, some fat-tailed distributions do not possess a mean.

Most VTT studies test various parametric forms, such as log-normal, log-uniform, and Weibull. Based on the best model fit, the distribution is determined. Commonly, a log-normal distribution is found to fit the VTT distribution well. The distributions that are tested are informed by economic theory, which indicates that the VTT must be positive, continuous, and possess a finite mean. However, the true shape of the distribution of the VTT in the population is unlikely to coincide exactly with a parametric distribution. A theory postulating that the VTT is distributed e.g. log-normal does not exist.

To recover the shape of distributions without imposing parametric structures *a priori*, nonparametric methods have been developed. In recent years, nonparametric methods have been used in VTT studies to determine the shape of the VTT distribution more accurately, and in particular of the right-hand side tail. As such, nonparametric methods are useful to underpin a decision for using the type of parametric distribution in latter discrete choice models. Additionally, they are helpful to establish whether the right-hand side tail of the distribution is sufficiently covered by the data. In this chapter, we use nonparametric analysis for these purposes.

6.2 Method

Numerous nonparametric techniques exist (e.g. Fosgerau 2007). Most nonparametric techniques suitable for VTT analysis require data in a 2-attribute-2-alternative form. Each technique has its strengths and weaknesses (Fosgerau 2007, Hernandez & van Cranenburgh 2023). Since nonparametric techniques are merely used to inform the decision on the parametric VTT distribution, it goes beyond the scope of this documents to revisit these pros and cons in detail.

We have used five nonparametric techniques. Some have been used in previous VTT studies, others have not.

- Local constant, which estimates the percentage of respondents that chooses the slow/cheap alternative depending on the BVTT (see equation [1]). The whole range of BVTTs are split into BVTT segments and for each interval a (local) constant is estimated. (to be more precise, it uses a kernel bandwidth around the centre points of each BVTT interval for this). The distribution that is obtained is considered an approximation for the cumulative VTT distribution, though a cumulative distribution must always be monotonic increasing whereas this may not necessarily be true for the result of the local constant analysis.
- Local logit, which is similar to local constant, but it estimates a logit model for each interval.
- Rouwendal method, in which it is assumed that everybody will choose the slow/cheap option if their own VTT is lower than the BVTT of the choice card, and the fast/expensive option otherwise. Based on the accept/reject pattern in a series of observed choices, their VTT is estimated in which they take a fixed probability of making a mistake (i.e. choosing an alternative that is inconsistent with their own VTT) is assumed.
- Artificial neural network: in this method an ANN is trained to predict the “last” choice based on all previous choices made by a respondent. The trained ANN is then used to find the BVTT for which each respondent is indifferent (i.e. is equally likely to choose the slow/cheap alternative and the fast/expensive alternative) which is used as a proxy for their VTT.

- Logistic regression: in this method a logistic regression is made on the series of choices for each respondent. The parameters of this regression provide a proxy for the respondent's VTT. This method is equivalent to the simplest version of an ANN.

6.3 Data

First, we have applied all five methods on data from SP1A-experiment, i.e. the experiment with only time and cost attributes. We selected respondents:

- travelling for commute or other purposes only (i.e. not travelling for business purposes)
- travelling by car, train or local PT only
- recruited from the internet panel only

These selections are made by balancing the needs for large data set on the one hand, and a homogeneous data sample on the other hand.[7] This selection resulted in 22,856 choices from 2,857 respondents[8].

6.4 Analysis of the SP1A-experiment

We have used all five techniques to learn about the shape of the VTT distribution (for all respondents in the data set). The main result is shown in Figure 12, in which also for each BVTT interval the percentage of respondents choosing the slow/cheap option is displayed ("empirical prob"). As might be expected the local constant and local logit methods follow the empirical distribution closely. The cumulative distributions from the other three methods lie above those from the first two methods and are a bit further away from the empirical distribution. This is because the last three methods consider that the empirical distribution also includes some error structure (errors made by the respondent, made while observing, imperfections in the model description) and these errors cause the empirical distribution to tend towards the 50%-line. The last three methods have very similar tails towards the high end of the VTT distribution, but they mainly deviate in the middle part (i.e. between €5 and €35).

[7] At this point in the analysis, it was not yet known that intercept respondents and internet panel respondents for train and local PT did not have a signifcantly different VTT.

[8] This non-parametric analysis was performed when the data filtering phase was not yet complete. This explains the small difference of 5 respondents between this number of respondents and the number in Table 9.

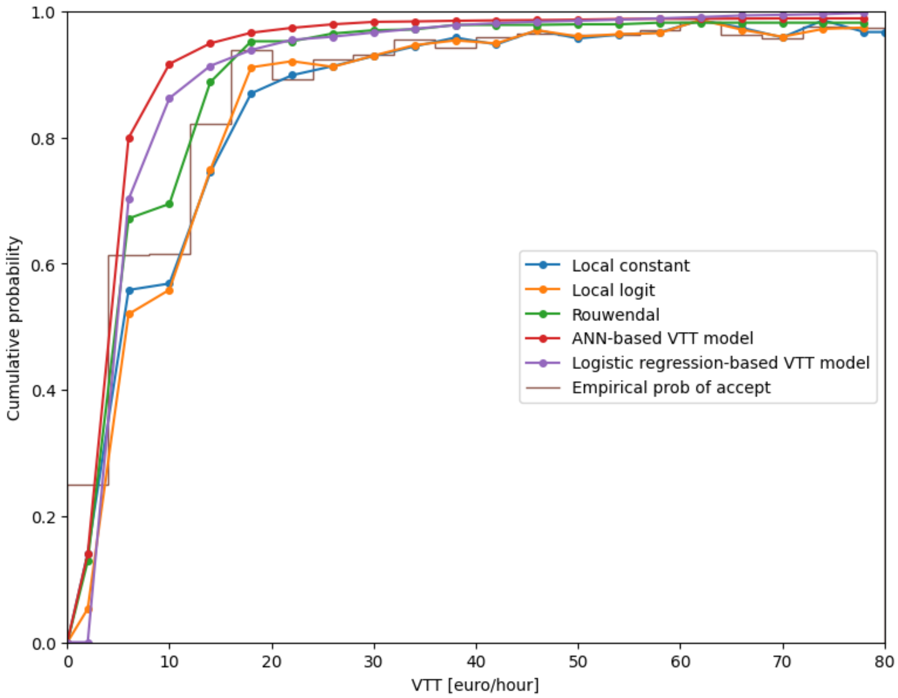


Figure 12 – Cumulative VTT distribution according to 5 non-parametric techniques.

Furthermore, the nonparametric results indicate that the tail of the distribution is well-covered by the data. If this were not the case, the upper right-hand sides of the distribution would have looked more erratic.

To enhance interpretation, Figure 13 shows histograms of the five recovered VTT distributions. However, it must be noted that the histograms are sensitive to the chosen bins.

Furthermore, the mean VTT is depicted in the plot title. What catches the eye is the large spread of the recovered mean VTTs across the five techniques. This reflects their considerable differences and supports the notion that the flexibility of nonparametric methods does not lead to more narrow estimates of the mean VTT.

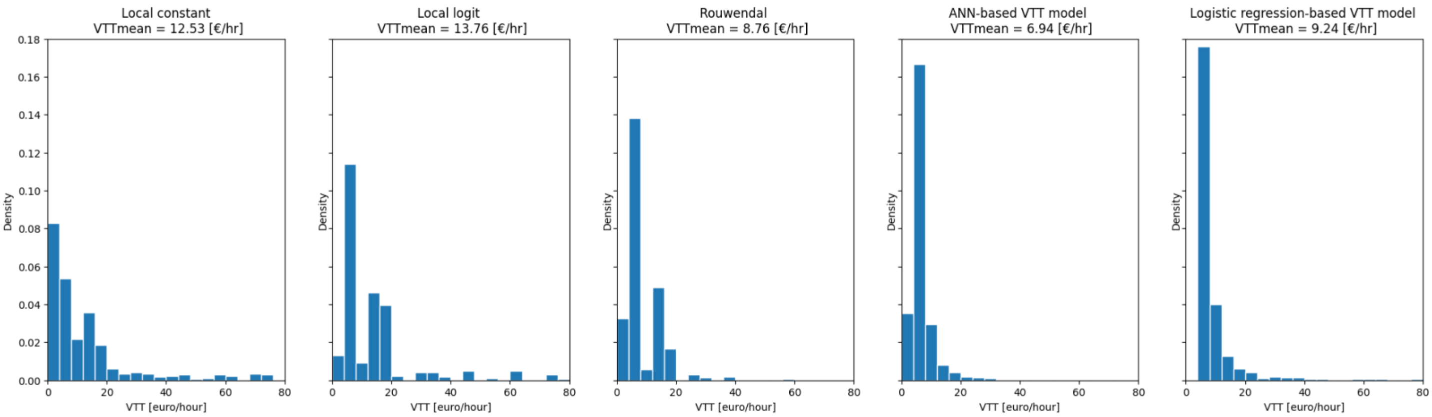


Figure 13 - VTT distribution according to 5 non-parametric techniques

Since our objective is to find a parametric distribution that accurately describes the VTT distribution in the data, our next step is fitting parametric distributions to the recovered distributions by the nonparametric techniques. In total, we fitted 87 parametric distributions. We ranked them based on plausibility (demanding that there is no tail towards negative VTT), simplicity (some distributions are not practical to implement in a logit estimation) and model fit, in which we focused on the fit to the distributions from the last three methods (that we consider more plausible since they do assume some error structure which is obviously present). The best three distributions are:

- Burr-distribution
- Inverse Weibull distribution
- Generalised Extreme Value distribution

The lognormal distribution ranked eight in this list, but differences between the top ten were generally small.

Figure 14 shows the smoothed distributions from the previous plot, the best three fitted distributions and the fitted lognormal distribution.

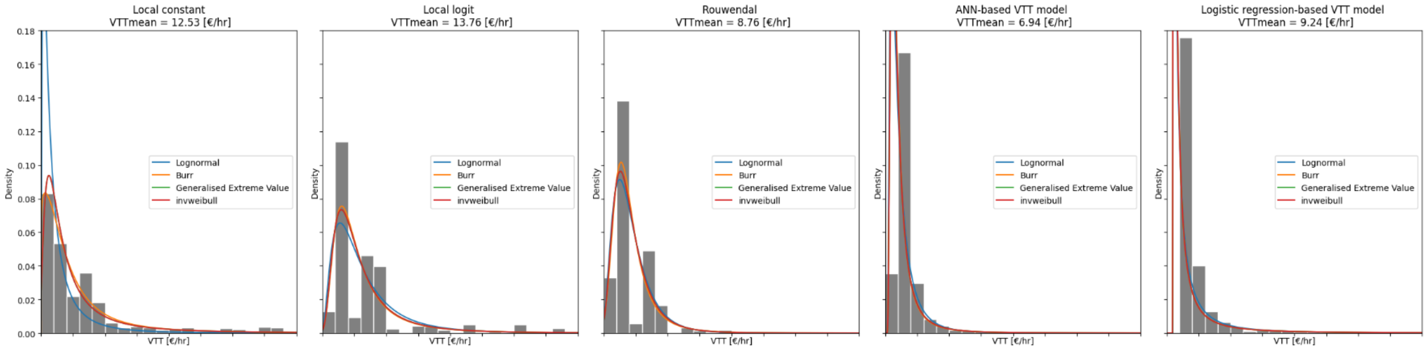


Figure 14 – Four parametric fits to the VTT distribution according to 5 non-parametric techniques

Based on Figure 14, the following conclusions can be drawn:

1. It is hard to select the overall best parametric distribution for the VTT. At least, visual inspection does not allow to draw such conclusions. But, also the fit statistics did not provide conclusive support for picking one distribution as the overall best one.
2. We find support for that the log-normal distribution is a good choice for modelling the VTT distribution in parametric models. We see that the log-normal distribution coincides well with the other three more exotic (and flexible) parametric distributions, perhaps with the exception for the left-hand side plot. This provides empirical support for the common use of the log-normal distribution in VTT studies.
3. Based on the recovered mean VTT and model properties (both are very flexible) the Rouwendal and ANN-based VTT method seem to have recovered the most plausible distributions.

6.5 Analysis of the SP2A-experiment

As discussed in Section 3.3.4, most respondents in SP2A saw 4 choice pairs that had equal costs for both alternatives, making them effectively a two-attribute sub-experiment within a three attribute experiment. On this sub set of data, we can apply the same non-parametric analysis techniques as were used on the SP1A data.

Again, we selected respondents for commute and other purposes that were travelling by car, train or local PT and that were recruited from the internet panel only. This selection resulted in 8,988 choices from 2,247 respondents.

We have applied the five non-parametric techniques on this dataset which now provides information on the shape of the reliability ratio (RR) distribution. The main result is shown in Figure 15. Again, we observe that the local constant and local logit methods follow the empirical distribution closely. The cumulative distributions from the other three methods lie above those from the first two methods (as was explained before). The mutual differences between these other three methods are larger than observed for the SP1A-data. This is probably the result of the smaller amount of data. However, they all indicate that a substantial fraction of the respondents have a very low RR (less than 0.1) and the remaining fraction of the respondents have an RR up to about 1.5. We can also conclude that the experiment covers the tail of the RR-distribution well.

Figure 16 shows histograms of the five recovered VTT distributions with some common distributions fitted to them. The mean RR is displayed above the distributions. The last three methods saw average values for the RR between 0.23 and 0.38.

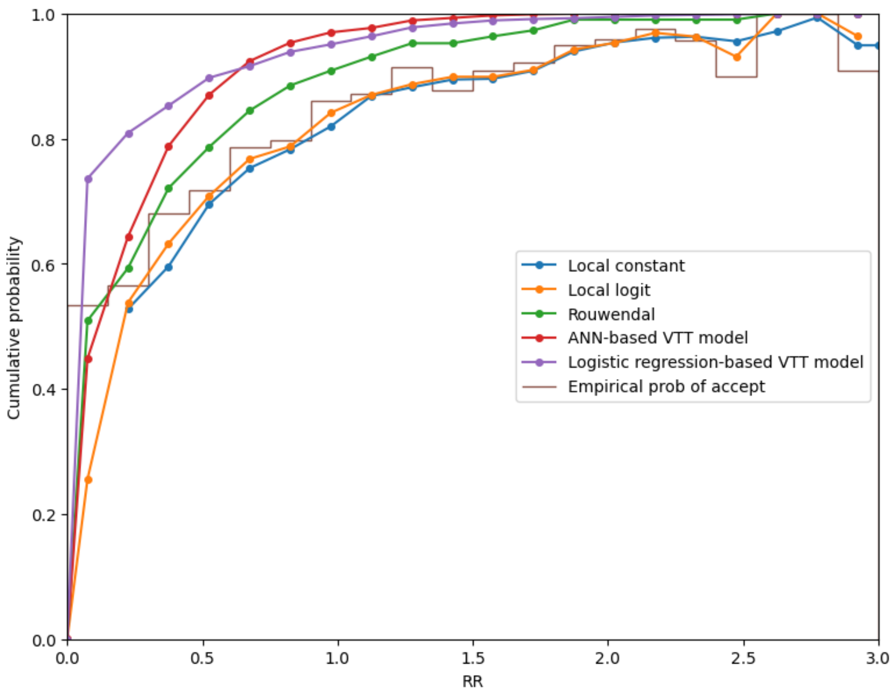


Figure 15 – Cumulative RR distribution according to 5 non-parametric techniques.

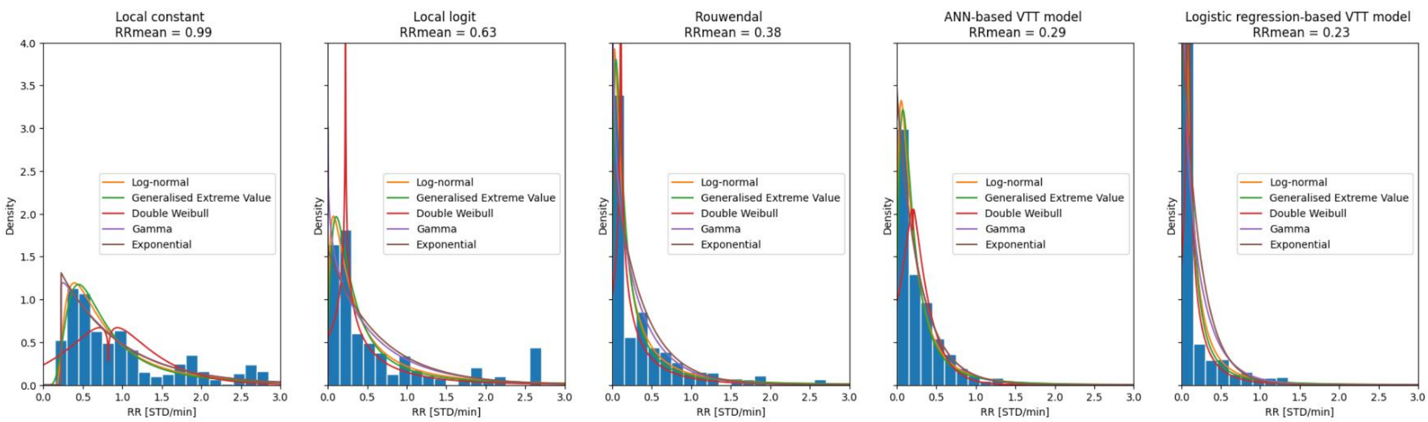


Figure 16 – Four parametric fits to the VTT distribution according to 5 non-parametric techniques

7. Development of the utility function

This section describes the utility function for each of the SP experiments. The first subsection describes the general modelling framework. The later sections describe for each experiment how the best models were developed.

7.1 General modelling approach

7.1.1 Possible approaches

The simplest utility function for a time-cost experiment has two terms for each of alternatives 1 and 2:

$$U_1 = \beta_C \cdot C_1 + \beta_T \cdot T_1$$

$$U_2 = \beta_C \cdot C_2 + \beta_T \cdot T_2 \quad [3]$$

This can be re-written such that the VTT is estimated directly:

$$U_1 = \mu \cdot (C_1 + VTT \cdot T_1)$$

$$U_2 = \mu \cdot (C_2 + VTT \cdot T_2) \quad [4]$$

in which μ is equal to β_C , i.e. the cost coefficient. This is called the linear Random Utility approach (RU-LIN). An alternative utility specification is the (linear) Random Valuation approach (RV-LIN), where the choice between the fast-and-expensive alternative and the slow-and-cheap alternative is modelled.

$$U_{fast} = \mu \cdot BVTT$$

$$U_{slow} = \mu \cdot VTT \quad [5]$$

in which BVTT is the boundary value of time (see equation [1]).

Several studies have shown that, in general, the RV-approach fits the choice data better. The downside of the RV-approach is that it can only be applied to a 2-attribute experiment whereas the RU-approach can also be used for 3- or more attribute experiments.

Another decision that needs to be made is the assumption about the error structure of the logit model. Usually, either additive or multiplicative errors are assumed. The RU- and RV-approaches above implicitly assume an additive error structure; the standard assumption in logit models. A multiplicative error structure assumes the error scales with the magnitude of the utility. By taking the logarithm of the above utility equations the multiplicative error structure can be modelled[9], so that the random utility approach with multiplicative error terms (RU-LOG) the following utility functions are used:

$$U_1 = \mu \cdot \log(C_1 + VTT \cdot T_1)$$

$$U_2 = \mu \cdot \log(C_2 + VTT \cdot T_2) \quad [6]$$

And in the random valuation structure with multiplicative error terms (RV-LOG) the following utility functions are used:

$$U_{fast} = \mu \cdot \log(BVTT)$$

$$U_{slow} = \mu \cdot \log(VTT) \quad [7]$$

Several studies have shown that the multiplicative error assumption fits the data better (both for the RU and the RV-approach), but this assumption also has some drawbacks which will be discussed later.

[9] Note that the VTT and attribute values are strictly positive real numbers, so that no computational issues can arise from the logarithmic term.

7.1.2 Test on data

A test was performed to check the RV-approach fits the data better for this new dataset and whether the assumption of multiplicative errors also results in better fitting models.

For this test, we selected the following subset of the data:

- Modes = car, train and local PT
- Purpose = commute and other (not business, since it is expected to have a clearly different VTT)
- BaseTime between 10 and 89 minutes (no tail towards very long trips)
- BaseCost between € 0.5 and € 15.99 (no tail towards very high costs)

Since the test is done without any further interaction terms, we selected respondents with a reasonably similar VTT. The remaining dataset contained 21408 choices from 2676 respondents. Four models were estimated according to RU-LIN (eq. [4]), RU-LOG (eq. [6]), RV-LIN (eq. [5]) and RV-LOG (eq. [7]).

Table 14 – Estimation result for test on modelling framework

	RU-LIN	RU-LOG	RV-LIN	RV-LOG
Final log (L)	-9621.1	-9238.8	-9559.9	-8445.1
Diff. log(L) with RU-LIN		+382.3	+61.2	+1176.0
Rho²(0)	0.352	0.377	0.356	0.431
mu	-1.261 (-49.9)	-11.76 (-52.3)	-0.1083 (-26.7)	-1.211 (-74.9)
vtt	6.546 (50.2)	5.667 (49.5)	5.106 (30.9)	3.426 (58.7)

As can be seen from Table 14, indeed the RV-approach produces better model fits than the RU-approach: both RV-models have better loglikelihoods than their RU-counterpart. Furthermore, the multiplicative error assumption fits the data better than the additive error assumption: both LOG-models have better loglikelihoods that their LIN-counterparts. The RV-LOG model has the best loglikelihood, and this is more than 1000 points better than that of the RU-LIN model, which has the worst loglikelihood.

7.1.3 Conclusion on the general modelling approach

After careful consideration, we have decided to use the RU modelling approach rather than the RV modelling approach, despite its worse performance in the test above, based on the following arguments:

- The RU-approach can also be used for the analysis of the experiments with more than two attributes. For the final models, we often use a joint estimation on data from a two-attribute experiment (e.g. SP1A) and data from a three or more attribute experiment (e.g. SP2A). For consistency reasons, we do not want to use different modelling approaches for different experiments in a joint estimation.

- The value of travel time (VTT) in equation [4] is equal to the ratio of the time coefficient and the cost coefficient from equation [2]. In other words, it is the ratio of the marginal utility of time divided by the marginal utility of cost. It can be shown that the VTT in equations [6] and [7] do not have the same interpretation, and are mathematically something (slightly) different.[10] Indeed, from Table 14 it is evident that the VTT from especially the RV-LOG model is clearly different from that of the RU-LIN model.

- In the 2014 UK VTT study (ARUP et al. 2015), the authors use the RV-LOG approach, but they acknowledge that the VTT from this approach "is likely to underestimate the true VTT". They add that "the error term [in the RV-LOG approach] likely captures not just noise, but also heterogeneity in the VTT". They claim that the VTT from the RV-LOG approach "relates more to a median than a mean VTT". Finally, they state that this issue disappears when mixed logit models are used "as the additional random components distributed across respondents then capture the random variation in VTT". However, this last conclusion has not been proven and based on private discussions with

[10] Based on ongoing research by Cranenburgh, Kouwenhoven, Dekker, Muller & de Jong (2023) which is expected to be published in 2024.

some of the authors, there remains some uncertainty regarding the interpretation of the VTT derived from the RV-LOG approach.

The results of this 2022 VTT study will be compared to the results of the 2009-2011 study in the Netherlands, which used a RU-LIN approach. This does not mean that we need to use the exact same methodology, but it does mean that we should be prudent with methodological changes. We only want to adopt methodological changes if underpinned with strong arguments for them; a change should be well argued or theoretically founded. Given that the VTT difference between RV-approach and the RU-approach is not well understood, we decided to stay with the RU-approach.

Next to the choice between the RU and RV-approach, there is also the choice between the assumption of additive or multiplicative errors. We decided to use the assumption of additive errors rather than multiplicative errors, based on the following arguments:

- When the RU-approach is used, the difference between the linear and logarithmic formulation strongly decreases if size effects of the trip (travel time and cost of the reference trip) are explicitly included in the model specification.
- It is our experience that estimating more advanced RU-LOG models can be very challenging. Allowing for non-linearities very often leads to negative arguments for the logarithm. This makes estimating these models a very complex and lengthy process.

The decision to use the RU-LIN approach has the additional benefit that we remain consistent with the earlier study – which is not an objective in itself, as discussed before – but alterations should be well argued.

7.2 Model development for SP1A – Value of travel time (car, train, local public transport, air)

The models for the SP1A experiments were developed in the following steps:

1. Base MNL-model. First step was to estimate an MNL model according to equation [3]. For each mode, a separate model was estimated. This is a slight deviation from the 2009/2011 study, where a separate model was estimated for each purpose[11]. However, we noted that in international studies it was common practice to estimate models by mode rather than by purpose. Furthermore, a test revealed that there is more explanatory power in models estimated by mode than in models estimated by purpose.

2. Adding interactions. Next, we added all candidate interaction factors irrespective on whether they were significant or not. The full list of interaction factors that were included:
   - Main interactions (applied separately on the mu and on the VTT coefficient)
     - BaseTime
     - BaseCost
     - Purpose
     - Income
   - Interactions with person-specific variables (applied on the VTT coefficient only)
     - Gender
     - Age class
     - Education level
     - Household size
     - Work situation (including being self-employed)
     - Recruitment type (panel or intercept)

[11] With an exception for air and recreational navigation for which a separate model by mode was estimated

- Interactions with trip-specific variables (applied on the VTT coefficient only)
  - Group size of the trip
  - Trip frequency
  - Travelling in the peak hour or not
  - Direction of the trip

The interactions with BaseTime and BaseCost are included with an elasticity. For example, we use the following specification for the interaction of VTT with BaseTime:

$$VTT_{ref} \cdot \left(\frac{BaseTime}{BaseTime0}\right)^{\lambda_T^{VTT}} \quad [8]$$

in which BaseTime0 is a reference value for the BaseTime. This implies that the estimated (reference) VTT applies to respondents making a trip with a duration of BaseTime0.

In principle, an arbitrary value for BaseTime0 and BaseCost0 can be chosen. However, to reduce the correlation between the estimated coefficients, it is prudent to chose a value not too far from its average value in the sample. For car, train and local public transport, we used BaseTime0 = 60 minutes and BaseCost0 = € 5. For air, we used BaseTime0 = 300 minutes and BaseCost0 = € 300.

Almost all other interaction variables are included in a multiplicative form. For example, we use the following specification for age and gender:

$$VTT_{ref} \cdot (1 + cf_{fem} \cdot \delta_{fem}) \cdot (1 + cf_{age2} \cdot \delta_{age2} + cf_{age3} \cdot \delta_{age3} + cf_{age4} \cdot \delta_{age4}) \quad [9]$$

in which δ_{fem}, δ_{age2}, δ_{age3} and δ_{age4} are dummy variables that indicate whether the respondent belongs yes (1) / no (0) to the specific category. The specification above implies that the estimated (reference) VTT applies to male respondents of age group 1. If cf_{fem} is found to be a factor of 0.1, this implies that female respondents have a 10% higher VTT compared to this reference group. If cf_{age2} is found to be a factor of -0.2, this implies that respondents of age group 2 have a 20% lower VTT. These factors should be multiplied: in this example, the VTT for female respondents of age group 2 is a factor (1 + 0.1) · (1 – 0.2) = 0.88 times the VTT of the reference group (i.e. 12% lower).

Only income is included as a combination of a continuous variable (for those respondents for which an income level is known) and a categorical interaction variable (for those respondents for which the income level is not known, either because the respondent did not know, or he/she did not want to tell):

$$VTT_{ref} \cdot \left(\left(\frac{Income}{Income0}\right)^{\lambda_{inc}^{VTT}} \cdot \delta_{hasIncome} + (1 + cf_{noIncome} \cdot (1 - \delta_{hasIncome}))\right) \quad [10]$$

in which $\delta_{hasIncome}$ is a dummy variable indicating whether the income of the respondent is known. For the scaling the income term, we used Income0 = € 70,000.

3. Constraining insignificant interactions. Insignificant interaction factors were removed (i.e. constrained to zero, or to another similar interaction factor) from the model. This was done for each mode separately, and in a step-by-step approach, starting with the parameters with the lowest t-ratios. Coefficients with a t-ratio below 1.96 were kept if:
   - a loglikelihood comparison showed that the coefficient was significant.[12]
   - there was no a-priori assumption that the parameter was equal to zero, or was equal to some other parameter

[12] Due to correlations, it sometimes happened that an interaction coefficient had a t-ratio well below 1.96, while removing it from the model still deteriorated the loglikelihood of the model by more than 1.92 points (which indicates that the interaction coefficient is significant at a 95% confidence level).

  - the coefficient was related to unknown income / unknown education level / unknown work situation if any other income / education / work situation interaction coefficient is estimated, to prevent bias on the reference level
  - it concerns the purpose, BaseTime or BaseCost interaction on the VTT, since these are at the core of this research.
4. (Not) including sign/size effects. Though including sign- and size-effects in the utility function resulted in a clear improvement of the model fit, there is no undisputed way in which they should be incorporated in the utility function. Further, in the sample enumeration it is always best to take an average over a wide range of ΔT and ΔC-combinations to mitigate any possible biases. A test revealed that the resulting VTT of such a sample enumeration using a utility function with sign- and size-effects is very similar to the one obtained with a much simpler/comprehendible model that does not explicitly includes sign and size effects. Therefore, it was decided that the simpler model without sign and size effects could be used for the final analysis.
5. Mixed logit. We replaced the constant VTT_{ref} coefficient by a random variable that is distributed within the population. From the non-parametric analysis described in Chapter 6, we conclude that the SP experiment covered the tail of the VTT distribution sufficiently to identify its shape and that a lognormal distribution fits the distribution of the VTT within the population very well. So, we assumed that the VTT was randomly distributed according to a lognormal distribution, described by two parameters: vtt_{mean} and vtt_{sigma}.

   Note that the decision on whether a coefficient was significant was only tested in the MNL model and this test was not repeated in the Mixed Logit model. Based on our experience, a coefficient that is significant in the MNL model remains significant in the Mixed Logit model, though its t-ratio may get lower due to correlation with the parameters that describe the distribution of the random variable.
6. Joint estimation. In the final step, a single model was estimated based on joint data from SP1A and SP2A data (see Section 7.5)

All MNL models were estimated with Biogeme (Bierlaire, 2023). Mixed logit models were estimated with Apollo (Hess & Palma, 2019a,b), due to problems we encountered with calculation times and with the calculation of the error margins of the estimated parameters in an earlier version of Biogeme. The instructions on how to solve this problem came too late for them to be used in this project. We performed checks that confirmed both software packages rendered equal results when estimating identical models.

7.3 Model development for SP1B – Value of travel time (cycling, walking)

In this experiment, walkers / cyclists were asked to choose between a (costless) walk / cycling trip and a quicker trip by an alternative mode for which they had to pay. Respondents were asked which modes they could have used as an alternative mode. If more than one alternative mode was mentioned, they were asked which of those modes they preferred. If only "car" was selected, or "car" was the preferred alternative mode, this mode was used as the alternative mode, otherwise "electric rental bike" was used as the alternative mode. If they already used an electric bike for their trip, they were instructed to assume that their electric bike was not available, so that they had to choose between a normal bike and an electric rental bike.

The base utility specification for the bike experiment is as follows:

$$\begin{aligned} Util_{bike} &= \mu \cdot (0 + VTT_{bike} \cdot TIME_{bike}) \\ Util_{alternative} &= \mu \cdot (COST_{alternative} + VTT_{alternative} \cdot TIME_{alternative} + ASC_{alternative}) \end{aligned} \quad [11]$$

Note that this is now a mode choice model, so we must include alternative specific constants. Note that μ is a scale factor, so it applies to the ASC as well. For the experiment on walking, we used a similar utility specification.

We used the same stepwise approach for developing the model as was used for SP1A.

- Separate $VTT_{alternative}$ and $ASC_{alternative}$ were estimated for car and electric rental bike (whichever was used in the experiment).

- We assumed that all interaction factors on the VTT applied both the VTT of the active mode and the VTT of the alternative mode.
- For the BaseTime interactions, we used the BaseTime of the reference trip using the active mode, with BaseTime0 = 30 minutes. No BaseCost interaction was included. For scaling the income interaction, we used Income0 = 70,000 which is the same as was used in SP1A.
- For the Mixed Logit model, we assumed that the VTT distribution for the active mode and the alternative mode had the same shape and only differed by a constant factor that could be estimated (in other words, we assumed that a respondent that has a relatively high VTT for cycling, also has a relatively high VTT for car and/or e-bike).

7.4 Model development for SP1C – Value of waiting time for a bridge/lock (recreational navigation)

For the analysis of this experiment, we exercised the same stepwise approach as was used for SP1A. Since this experiment concerned the waiting time and cost to pass a bridge/lock – the (reference) time and cost for the total trip were not relevant – no interactions with BaseTime and BaseCost were tested.

Furthermore, the cost for passing a bridge of lock were multiplied by factor 1.0635[13] to compensate for 100% of the inflation and 50% of the real income growth between 2021 (when this data was collected) and 2022 (when all other survey data was collected), so that all final results of the models are expressed in 2022 price levels. This correction is consistent with the standard practice in the Netherlands for cost-benefit analysis (see Appendix D).

7.5 Model development for SP2A (joint with SP1A) – Value of travel time reliability (car, train, local public transport, air)

The reliability experiment was performed by all car respondents, by about 60% of the public transport respondents and by about 50% of the air respondents. For those modes, a random draw determined whether a respondent participated in this or in another experiment.

10% of the non-business respondents got a set of 8 choice questions based on the same underlying design that was used in the 2009/2011 study. Because of some issues in the presentation of the attributes both in this study and in the 2009/2011 study[14], these choices cannot be used to determine the value of reliability. Therefore, they are excluded from the analysis.

The remaining 90% got 8 choice questions based on a new underlying design in which 4 choice pairs had a cost difference between the two alternatives and 4 choice pairs had equal costs for both alternatives, making them effectively a two-attribute sub-experiment within a three-attribute experiment. The four boundary reliability ratios (BRR, i.e. the equivalent of a boundary value of time in the SP1A experiment) for each respondent were equally distributed over the range of possible BRRs.

The utility function for the base model is formulated as follows. For the choice tasks with a cost difference, we used the following utility function (for both alternatives):

$$Util_{CostDiff} = \mu_{cost} \cdot \left(COST + VTT \cdot (TIME + RR \cdot STDEV)\right) \qquad [12]$$

in which RR is the reliability ratio (equal to the ratio of the value of travel time reliability and the value of travel time):

$$RR = \frac{VTTR}{VTT} \qquad [13]$$

For the choice questions without a cost difference (i.e. with the same cost for both alternatives), we used the following utility function.

[13] The Consumer Price Index (CPI) increased by 10.0% between 2021 and 2022. The wage rate (“loonvoet”) decreased by 6.7% in real terms.

[14] For more details on this, see section 13.2.

$$Util_{CostSame} = \mu_{time} \cdot (TIME + RR \cdot STDEV) \quad [14]$$

Naively, one might think that μ_{time} is equal to $\mu_{cost} \cdot vtt$, so that both types of utility functions can be combined into a single utility function. However, this may only be done if one also allows for a different scale for both (sub)experiments: [15]

$$Util = \left(sc_{CostDiff} \cdot \delta_{CostDiff} + sc_{CostSame} \cdot \delta_{CostSame}\right) \cdot \mu_{cost} \cdot \left(COST + VTT \cdot (TIME + RR \cdot STDEV)\right)$$

[15]

in which we can constrain $sc_{CostDiff}$ to be equal to 1.

For each mode, it was assumed that the interaction factors were identical to the set of interaction factors that were kept in the final SP1A model. No new specification research was done on SP2A data alone.

For the Mixed Logit model, we tested three options:

- a model with a randomly distributed VTT variable, but with a constant RR. This model implies that the ratio between the VTTR and VTT is for all respondents the same.
- a model with both a randomly distributed VTT variable and a (independently) randomly distributed VTTR variable. This model fits the data significantly better than the first model, indicating that the RR is not constant within the population. This is consistent with the findings from our non-parametric analysis on the SP2A cost-same data (Section 6.5).
- a model similar to the previous one, but with a VTT and a VTTR distribution that were partly correlated and for which the correlation factor ρ was estimated. This again was a significant model improvement over the previous one, indicating that the VTT and VTTR of respondents are not fully independent.

In a final step, a joint estimation with data from both the SP1A and SP2A experiment was executed. In this step, an additional scale factor was added to the utility function to allow for a possible scale difference between both experiments (which is to be expected given the different level of complexity between a two- and a three-attribute experiment). Moreover, an additional interaction factor on the VTT was added on to allow for a difference in the VTT in the SP1A and the SP2A experiment as researchers previously have found (see Hess et al. 2020).

7.6 Model development for SP2B – Value of travel time comfort (cycling, walking)

This experiment is different from all others, since it is the only one that only has a time attribute and does not have a cost attribute. Since it has only one attribute in common with SP1B, it is not useful to estimate a joint model with another experiment. Therefore, the utility function for this experiment was developed fully independently using the following steps.

1. Base MNL-model. We used the following structure as the base model for the cycling respondents:

$$\begin{aligned} U = \beta_T &\cdot \left(1 + \textstyle\sum_{i=2}^{8} cf_{path(i)} \cdot \delta_{path(i)}\right) \\ &\cdot \left(1 + \textstyle\sum_{j=2}^{4} cf_{pave(j)} \cdot \delta_{pave(j)}\right) \\ &\cdot \left(1 + \textstyle\sum_{k=2}^{4} cf_{ncar(k)} \cdot \delta_{ncar(k)}\right) \\ &\cdot \left(1 + \textstyle\sum_{l=2}^{4} cf_{rout(l)} \cdot \delta_{rout(l)}\right) \cdot TIME \end{aligned} \quad [16]$$

   where for each of the level of the four other attributes (path configuration (path), pavement (pave), number of bypassing cars (ncar) and beautifulness of the route (rout)) a coefficient is estimated. The first level is always used as the reference level.

   Since in this formulation the time coefficient is multiplied by several factors each referring to one attribute, this is called the multiplicative formulation. We also tested other formulations, such as

[15] If scale factors are omitted, the estimation often results in negative values for the reliability ratio.

the additive formulation in which all attribute coefficients are added before being multiplied by the time:

$$U = \beta_T \cdot \left(1 + \sum_{i=2}^{8} cf_{path(i)} \cdot \delta_{path(i)} + \sum_{j=2}^{4} cf_{pave(j)} \cdot \delta_{pave(j)} + \sum_{k=2}^{4} cf_{ncar(k)} \cdot \delta_{ncar(k)} + \sum_{l=2}^{4} cf_{rout(l)} \cdot \delta_{rout(l)} \right) \cdot TIME \quad [17]$$

The additive and multiplicative formulation gave similar results in terms of model fit. However, the additive formulation might lead to inconsistencies (adding all effects of improvements together might lead to negative numbers).

We also tested a dummy formulation where the attributes add a constant amount to the utility function irrespective of the travel time:

$$U = \beta_T \cdot TIME + \sum_{i=2}^{8} cf_{path(i)} \cdot \delta_{path(i)} + \sum_{j=2}^{4} cf_{pave(j)} \cdot \delta_{pave(j)} + \sum_{k=2}^{4} cf_{ncar(k)} \cdot \delta_{ncar(k)} + \sum_{l=2}^{4} cf_{rout(l)} \cdot \delta_{rout(l)} \quad [18]$$

This full dummy formulation led to the best model fit, but the multiplicative formulation has effects that are proportional to travel time. This is behaviourally more plausible and provides multipliers that can be multiplied by the VTT. This is easier for interpretation and implementation in transportation models.

2. Adding interactions on the time coefficient. Given the relatively low number of respondents and since we only have a time coefficient, we limited the interactions to only an interaction between this time coefficient and the BaseTime. This means that we replaced β_T by

$$\beta_T \cdot \left(\frac{BaseTime}{BaseTime0}\right)^{\lambda_T} \quad [19]$$

3. Adding interactions between attributes. We tested whether the PATH-coefficient (i.e. the coefficient for the road configuration) interacted with the NCAR-coefficient (i.e. the coefficient for the number of by-passing cars). *A priori*, one might expect that "many cars" on a road with e.g. a separate cycle lane is valued differently from a road in which cars and bicycles share space. Indeed, we found that these correlations exist, so we estimated separate NCAR coefficients for all groups of the PATH attribute levels separately and grouped those that were not significantly different.

4. Testing interaction with inside/outside residential area. We tested if the model coefficients were different for respondents who made a trip inside or outside a residential area ("binnen/buiten de bebouwde kom"). Based on quick inspection, only one coefficient might be different (with a small difference anyway). However, it is more likely that this was just caused by noise. We conclude that it is not necessary to explore this further.

5. Testing interactions with purpose. We tested whether the model coefficients were different for respondents who made a trip for commute, business or other reasons. Based on quick inspection, three PATH-coefficients in the cycling model might have been different. Since the limited difference, it was decided that it was unlikely that the model would improve substantially by estimating separate coefficients by travel purpose.

6. Setting the reference level. Initially the first attribute level was chosen to be the reference level. However, this is an arbitrary choice. In principle, any level can be chosen. For each attribute we shifted the reference level to the average level. For the calculation of this average, we used the weights from the sample enumeration (see) multiplied by the travel time so that we get a travel time-weighted average that is consistent with the calculation of the national average VTT.

7.7 Model development for SP2C (joint with SP1C) – Value of reliability of waiting times for bridge / lock (recreational navigation)

For the analysis of this experiment, we used the same stepwise approach as was used for SP2A.

7.8 Model development for SP3A (joint with selection of SP1A) – Value of travel time comfort (public transport trip components)

The models for the SP3A experiment were developed in the following steps:

1. Base MNL-model. The first step was to estimate an MNL model based on the same structure as was used for SP1A (see equation [3]). However, in SP3A, three additional attributes were present: access/egress time, total wait and transfer time and number of transfers. Given the objective of the study, it was decided to include these in the utility function as a multiplier on the value of in-vehicle travel time. So, the base utility function is:

$$Util \;=\; \mu_{cost} \cdot \left(COST + vtt \cdot \left(TIME + fac_{aetm} \cdot AETM + fac_{WTTM} \cdot WTTM + fac_{ntrf} \cdot NTRF\right)\right) \qquad [20]$$

with

AETM = (combined) access/egress time

WTTM = total wait and transfer time

NTRF = number of transfers

For train and local public transport separate models were estimated.

2. Adding interactions on the cost and vtt coefficients. Given the relatively low number of respondents, we limited the interactions to interactions between the cost and VTT coefficients with BaseTime and BaseCost. This means that we replaced μ_{cost} by

$$\mu_{cost} \cdot \left(\frac{BaseCost}{BaseCost0}\right)^{\lambda_{mu}^{c}} \cdot \left(\frac{BaseTime}{BaseTime0.}\right)^{\lambda_{mu}^{t}} \qquad [21]$$

and we replaced vtt by

$$vtt \cdot \left(\frac{BaseCost}{BaseCost0}\right)^{\lambda_{vtt}^{c}} \cdot \left(\frac{BaseTime}{BaseTime0}\right)^{\lambda_{vtt}^{t}} \qquad [22]$$

where we used BaseCost0 = € 25 and BaseTime0 = 90 minutes for scaling the BaseCost and BaseTime terms.

3. Testing non-linearities and other interactions. We studied whether the multiplier factors were non-linear. For this we tested piece-wise linear function with 4-6 intervals (with boundaries determined such that each interval had roughly the same number of observations). This was tested for train and local PT separately. From this analysis we conclude that there are no significant (and plausible) non-linearities found, so a linear specification of the multiplier remains the best.

   We also examined if the valuation of a transfer is different if the current trip does or does not include a transfer, but it turned out to not be the case.

4. Joint estimation with SP1A. The final model was jointly estimated with data from SP1A to strengthen the determination of the multipliers, and to ensure consistency with the value of travel time (to which the multipliers are applied). We only used SP1A data from the same set of respondents that were included in SP3A, since the selection of respondent that participated in SP3A was not randomly chosen (see Section 3.3.7). A scale factor was added to compensate for the difference in complexity (and hence the difference in the error term) between both experiments.

   By jointly estimating the VTT on SP1A and SP3A data, we assumed that the VTT for the door-to-door travel time (as measured in the SP1A-experiment) is the same as the VTT for the in-vehicle travel time (as measured in the SP3A experiment). In general, these VTTs might be different (only if the in-vehicle time is close to the door-to-door travel time, they are the same). However, this was a necessary step to get coefficient estimates with reasonable t-ratios. Furthermore, we believe this assumption should have limited effect on the multipliers which were the objective of this experiment.

7.9 Model development for SP4A (joint with selection of SP1A) – Value of travel time comfort (public transport crowding)

The models for the SP4A experiment were developed in the following steps, which are similar to those for SP3A:

1. Base MNL-model. We used the following base utility function:

$$Util \;=\; \mu_{cost} \cdot \left(COST + vtt \cdot \left(TIME + dum_{crwd} \cdot CRWD\_LEV + dum_{sest} \cdot SEST\_LEV + fac_{intt} \cdot \frac{1}{FREQ} \right) \right)$$

[23]

with

CRWD_LEV = the level of crowding (ranging from 1 to 8)

SEST_LEV = seat/stand level (ranging from 1 to 2): you can sit or you have to stand

FREQ = the frequency of the public transport alternative

For train and local public transport separate models were estimated.

2. Adding interactions on the cost and VTT coefficients. The same BaseTime and BaseCost interactions were added as for SP3A (see equations [21] and [22]).

3. Testing non-linearities. We studied whether the multiplier for frequency was non-linear. For this we tested piece-wise linear function with 4 intervals. This was tested for train and local PT separately. From this analysis we conclude that there are no significant (and plausible) non-linearities found for train, but a diminishing sensitivity was indeed found significant for local PT. Hence a linear specification of the frequency multiplier remains the best for the train model, but a logarithmic specification works nicely for local public transport.

   For crowding, we concluded that a constant multiplier for levels 1-4 is the best formulation, and a linear formulation for the higher crowding levels, with a constant offset for standing in the train model, and a different slope for the level of crowding while standing for the local PT model.

4. Joint estimation with SP1A. Similar as was done for SP3A. In this case, we only used SP1A data from the same set of respondents that were included in SP4A.

   By jointly estimating the VTT on SP1A and SP4A data, we assumed that the VTT for the door-to-door travel time (as measured in the SP1A-experiment) is the same as the VTT for the in-vehicle travel time (as measured in the SP4A experiment). In general, these VTTs might be different (only if the in-vehicle time is close to the door-to-door travel time, they are the same). However, this was a necessary step to get coefficient estimates with reasonable t-ratios. Furthermore, we believe this assumption should have limited effect on the multipliers which were the objective of this experiment.

7.10 Model development for SP5A (constrained on SP1A) – Value of access travel time to an airport

The models for the SP5A experiment were developed in the following steps, which are similar to those for SP3A and SP4A:

1. Base MNL-model. We used the following base utility function:

$$Util \;=\; \mu_{cost} \cdot \left(COST + vtt \cdot \left(TIME + \sum_i dum\_airp_i \cdot \delta_i^{airp} + \sum_j dum\_pmis_j \cdot \delta_j^{pmis} \right) \cdot (1 + cf_{mode} \cdot \delta_{mode}) \right)$$

[24]

with

dum_airp = dummy coefficient for each level of the additional time at the airport, which can be interpreted as an equivalent travel time

dum_pmis = dummy coefficient for each level of probability of missing a flight, which can be interpreted as an equivalent travel time

cf_mode = interaction coefficient for the mode used for access to the airport (park&fly, kiss&fly, taxi or public transport)

2. Adding interactions on the cost and VTT coefficients. Similar BaseTime and BaseCost interactions were added to the model as for SP3A (see equations [21] and [22]). We used BaseTime0 = 90 minutes and BaseCost = € 25 to scale the BaseTime and BaseCost terms.

3. Adding additional interactions and constraining these to their values from the SP1A-air model. The objective of this experiment was to determine the *absolute* value of travel time for multiple access modes, rather than a (relative) multiplier as was determined in SP3A and SP4A. Therefore, it was decided not to do a joint estimation with SP1A data, since the addition of the SP5A would have led to slightly different coefficients compared to the SP1A-only estimation. In contrast, the SP5A model was estimated with the same interactions as were used in the SP1A model, and their coefficients were constrained to the estimates from the SP1A model. For practical reasons, the VTTs for the access modes were estimated as a multiplier on the (randomly distributed) VTT for the in-flight time, but for the final values they are presented as absolute values.

7.11 Model development for SP6A (constrained on SP1A) – Value of egress travel time from an airport

The models for the SP6A experiment were developed in the same steps as those for SP5A; the only difference being that the base model does not include terms related to the additional time spent at the airport and the probability of missing a flight, since these were not shown as attributes in this SP experiment.

8. Estimation results

This chapter contains the estimation results for all 15 models that were described in the previous chapter. The discussion of these models is grouped in the following way (each number refers to a Section within this Chapter):

1. joint SP1A/SP2A results for car, train, local public transport (these 3 models will be used for the determination of the VTT and VTTR for these modes in the following chapters);
2. joint SP1A/SP2A results for air transport + SP5A and SP6A results for access/egress to/from the airport (which use interaction coefficients that are constrained to the SP1A/SP2A results for air (these 3 models will be used for the determination of the VTT and VTTR for air and the VTT for airport access/egress in the following chapters);
3. SP1B results for cycling and walking (these 2 models will be used for the determination of the VTT for these modes in the following chapters);
4. Joint SP1C/SP2C results for recreational navigation (this model will be used for the determination of the VTT and VTTR for these modes in the following chapters);
5. SP3A and SP4A results (jointly estimated with a selection of SP1A data) for train and local public transport (these 4 models will be used for the determination of the comfort multipliers for these modes in the following chapters);
6. SP2B results for cycling and walking (these 2 models will be used for the determination of the VTT and VTTR for the comfort multipliers in the following chapters).

Each section starts with a table with the full estimation results, followed by a subsection with a short discussion of the results. Note that this discussion will only concern the estimated coefficients and (not yet) the resulting VTT, VTTR or comfort multipliers, since the latter will be discussed after the national average for these variables are calculated (see Chapter 9).

8.1 Joint SP1A/SP2A results for car, train, local public transport

8.1.1 Estimation results

The following utility function was estimated, in which

- red variable names indicate parameters that are estimated;
- variable names in CAPITALS indicate variables that are presented in the SP alternative;
- variable names with a δ are dummy variables, i.e. indicators that are 0 or 1. For example: δ_{purp2} = 1 if purpose = 2, and δ_{purp2} = 0 for purpose <> 2;
- the titles in the last column indicate the type of parameters.

The parameter estimates for the best models are displayed in Table 15. In this table, an explanation for each parameter is given. The parameters are grouped in the same way as the titles in the utility function. A legend on the explanation of the symbols can be found at the bottom of the table.

$$V = mu \cdot \left(1 + sc\_sp2 \cdot \delta_{sp2}\right) \cdot \left(1 + sc\_cstsame * \delta_{costsame}\right)$$

Scale factors

$$\cdot \left(\frac{BaseTime}{BaseTime0}\right)^{lmda\_t\_mu} \cdot \left(\frac{BaseCost}{BaseCost0}\right)^{lmda\_c\_mu} \cdot \left(\left(\frac{Income}{Income0}\right)^{lmda\_i\_mu} \cdot \delta_{hasIncome} + \left(1 + cf\_noinc\_mu \cdot \left(1 - \delta_{hasIncome}\right)\right)\right)$$

Continuous interaction variables on scale

$$\cdot \left(1 + cf\_busi\_mu \cdot \delta_{purp2} \cdot \left(1 + cf\_wtp2\_mu \cdot \delta_{wtp2} + cf\_wtp4\_mu \cdot \delta_{wtp4}\right) + cf\_othr\_mu \cdot \delta_{purp3}\right)$$

Categorical interaction variables on scale

$$\cdot \Big(COST + \big(vtt \cdot TIME + vttr \cdot STDEV \cdot \left(1 + cf\_vttrpurp2 \cdot \delta_{purp2} + cf\_vttrpurp3 \cdot \delta_{purp3}\right)$$

Reference VTT + VTTR + categorical trip interaction variables on VTTR

$$\big) \cdot \left(\frac{BaseTime}{BaseTime0}\right)^{lmda\_t\_vtt} \cdot \left(\frac{BaseCost}{BaseCost0}\right)^{lmda\_c\_vtt} \cdot \left(\left(\frac{Income}{Income0}\right)^{lmda\_i\_vtt} \cdot \delta_{hasIncome} + \left(1 + cf\_noinc \cdot \left(1 - \delta_{hasIncome}\right)\right)\right)$$

Continuous interaction variables on vtt and vttr

$$\cdot \left(1 + cf\_purp2 \cdot \delta_{purp2} \cdot \left(1 + cf\_wtp2\_vt \cdot \delta_{wtp2} + cf\_wtp4\_vt \cdot \delta_{wtp4}\right) + cf\_purp3 \cdot \delta_{purp3}\right)$$
$$\cdot \left(1 + \sum_{i=1}^{6} cf\_frq(i) \cdot \delta_{frq(i)}\right) \cdot \left(1 + \sum_{i=1}^{3} cf\_gs(i) \cdot \delta_{gs(i)}\right)$$
$$\cdot \left(1 + cf\_offpeak \cdot \delta_{offpeak} + cf\_peak \cdot \delta_{peak}\right) \cdot \left(1 + \sum_{i=1}^{3} cf\_drctn(i) \cdot \delta_{dirctn(i)}\right)$$

Categorical trip interaction variables on vtt and vttr

$$\cdot \left(1 + cf\_male \cdot \delta_{male} + cf\_female \cdot \delta_{female}\right) \cdot \left(1 + \sum_{i=1}^{4} cf\_agecat(i) \cdot \delta_{agecat(i)}\right)$$
$$\cdot \left(1 + \sum_{i=1}^{5} cf\_edu(i) \cdot \delta_{edu(i)}\right) \cdot \left(1 + \sum_{i=1}^{4} cf\_hhsize(i) \cdot \delta_{hhsize(i)}\right) \cdot \left(1 + \sum_{i=1}^{5} cf\_wrksit(i) \cdot \delta_{wrksit(i)}\right)$$
$$\cdot \left(1 + cf\_nozzp \cdot \delta_{nozzp} + cf\_zzp \cdot \delta_{zzp}\right) \cdot \left(1 + cf\_panel \cdot \delta_{panel} + cf\_interce \cdot \delta_{interce}\right)$$

Categorical personal interaction variables on vtt and vttr

$$\cdot \left(1 + cf\_sp2 \cdot \delta_{sp2}\right)$$

Categorical experiment interaction on vtt and vttr

$$\Big)$$

Table 15 – Estimated coefficients for joint SP1A/2A models for car, train, local public transport

	CAR		TRAIN		LOCAL PT		Remarks
Observations	30496		16704		15600		
Final log (L)	-12572.1		-6482.5		-6087.7		
D.O.F.	36		32		34		
Rho²(0)	0.405		0.44		0.437		
Reference value of travel time							
vtt_m	2.030	(28.2)	2.254	(8.5)	1.918	(20.5)	Mean and standard deviation of the distribution of ln(vtt) which applies to a respondent with all var's at their reference level
vtt_sigma	0.7915	(21.9)	0.6200	(8.5)	0.7308	(11.9)	
Reference value of travel time reliability							
vttr_m	-0.3474	(-2.2)	-0.1351	(-0.1)	-0.8136	(-1.6)	Mean and standard deviation of the distribution of ln(vttr) which applies to a respondent with all var's at their reference level
vttr_sigma	1.669	(29.6)	1.694	(4.7)	2.263	(9.3)	
rho	0.4609	(17.7)	0.1739	(0.7)	0.6347	(19.2)	Correlation coefficient of the randomly distributed vtt and vttr
Continuous interaction variables on vtt and vttr							
lmda_c_vtt	0.3339	(7.0)	0.3142	(6.4)	0.4374	(8.0)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 5 EUR.
lmda_t_vtt	0.04922	(0.8)	-0.01910	(-0.3)	-0.08823	(-1.2)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min. This coefficient is kept irrespective of its significance level due its importance for this study.
lmda_i_vtt	0.1996	(4.0)	0.1094	(3.5)	0.06687	(1.9)	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR. Income refers to yearly household income before taxes.
cf_noinc	-0.03952	(-0.6)	-0.04342	(-0.6)	0.03419	(0.3)	Interaction factor for respondents with unknown income level. This coefficient is kept irrespective of its significance level if any other education interaction coefficient is estimated, to prevent bias on the reference level.

	CAR		TRAIN		LOCAL PT		Remarks
Categorical trip interaction variables on vtt and vttr							
cf_purp1	0	(*)	0	(*)	0	(*)	Purpose = commute (reference level)
cf_purp2	0.4303	(4.5)	0.1448	(0.7)	0.3288	(2.8)	Purpose = business. This and the following interaction factors are kept irrespective of their significance level since no a-prioir assumption can be made that these should be zero.
cf_wtp2_vt	2.927	(2.8)	8.257	(0.9)	5.757	(1.9)	Purpose = business. Additional interaction for so-called “WTP-method” to determine business VTT (see Appendix B).
cf_wtp4_vt	0.7410	(1.0)	3.468	(0.6)	0.9683	(1.0)	Purpose = business. Additional interaction for so-called “WTP-method” to determine business VTT (see Appendix B).
cf_purp3	-0.1231	(-2.2)	-0.1814	(-2.8)	0.04103	(0.6)	Purpose = other
cf_frq1	-		-0.2263	(-2.0)	-0.06192	(-1.0)	Frequency = one-time trip
cf_frq2	-		-0.1509	(-1.0)			Frequency = once/several times per year. cf_freq12 is significantly different from zero despite its low t-ratio
cf_frq3	-				-		Frequency = once/several times per month. Constrained to 0 for car because of an implausible value / inconsistent with other coeffs
cf_frq4	-				-		Frequency = 1-2 times per week
cf_frq5	0	(*)	0	(*)	0	(*)	Frequency = 3-4 times per week (reference level)
cf_frq6	0.1166	(1.0)	-		-		Frequency = 5 or more times per week
cf_gs_1	0	(*)	0	(*)	0	(*)	Group size = 1 person (reference level)
cf_gs_oth2	x		-		-		Group size = 2 persons or more. Not tested for car.
cf_gs_2	-		x		x		Group size = 2 persons. Only tested for car, but not significantly different from reference level.
cf_gs_car3	0.2323	(2.4)	x		x		Group size = 3 persons or more. Only tested for car.
cf_offpeak	0	(*)	0	(*)	0	(*)	Period of the day = off peak (reference)
cf_peak	0.09261	(1.6)	-		0.1006	(1.5)	Period of the day = peak, i.e. the midpoint of the trip falls between 7:00 and 9:00 or between 16:00 and 18:00. cf_peak is significant for bus/tram/metro despite low t-ratio.
cf_dirctn1	0	(*)	0	(*)	0	(*)	Direction = outward trip
cf_dirctn2	-		-		-		Direction = return trip. Never sig different from cf_dirctn1
cf_dirctn3	-		-		-		Direction = other (i.e. non-home based trip). Constrained to 0 for train because of an implausible / uncertain value.
Categorical personal interaction variables on vtt and vttr							
cf_male	-		-		-		Gender = male (reference level)
cf_female	-		-		-		Gender = female. Not sign different from cf_male for any mode.
cf_agecat1	0	(*)	0	(*)	0	(*)	Age = 16-35 (reference level)
cf_agecat2	-		-		-		Age = 36-50
cf_agecat3	-0.1843	(-4.5)	-0.1110	(-1.0)	-0.06739	(-0.8)	Age = 51-65
cf_agecat4	-0.3061	(-4.0)			-0.3250	(-4.3)	Age = 66+.
cf_edu1	-0.2327	(-3.9)	-		-0.2024	(-4.0)	Education level = LO/MAVO/VBO/VMBO/LBO
cf_edu2	-0.09672	(-1.9)	-				Education level = MBO.
cf_edu34	0	(*)	0	(*)	0	(*)	Education level = HAVO/VWO/HBO/WO (reference level). Level 3 (HAVO/VWO) had an implausible value for train and was not significantly different from level 4 (HBO/WO) for any other mode.
cf_edu5	0.2697	(1.1)	-		-0.1786	(-0.8)	Education level = Other. This coefficient is kept irrespective of its significance level if any other education interaction coefficient is estimated, to prevent bias on the reference level.
cf_hhsiz12	0	(*)	0	(*)	0	(*)	Household size = 1 or 2 persons (reference level). Level 1 (1 pers.) was not sign. different from level 2 (2 pers) for any mode.
cf_hhsiz34	-0.1164	(-2.7)	-		-0.08410	(-1.7)	Household size = 3 or more persons. Level 3 (3 persons) was tested separately from level 4 (4 persons or more), but these levels were not significantly different for any mode.
cf_wrksit1	0	(*)	0	(*)	0	(*)	Work situation = employed (reference level)
cf_wrksit2	-		-0.2578	(-2.7)	-0.2330	(-3.1)	Work situation = unemployed
cf_wrksit3	-		-0.2443	(-2.8)	-		Work situation = student. Constrained to 0 for car because of an implausible value
cf_wrksit4	-		-		-		Work situation = retired
cf_wrksit5	-		-0.2396	(-1.1)	-0.1328	(-0.7)	Work situation = other. This coefficient is kept irrespective of its significance level if any other work situation interaction coefficient is estimated, to prevent bias on the reference level.
cf_nozzp	0	(*)	0	(*)	0	(*)	ZZP-type = no
cf_zzp	0.2350	(1.3)	-0.2503	(-2.9)	-		ZZP-type = yes (self-employed)
cf_panel	0	(*)	0	(*)	0	(*)	Recruitment type = panel (reference level)
cf_interce	0.1555	(2.5)	-		-		Recruitment type = intercept. Only for car this interaction factor was significantly different from 0.
Categorical trip interaction variables on vttr							
cf_vttrpurp1	0	(*)	0	(*)	0	(*)	Purpose = commute (reference level)
cf_vttrpurp2	-0.2252	(-2.5)	-0.6663	(-1.2)	-0.05878	(-0.2)	Purpose = business
cf_vttrpurp3	0.2667	(1.3)	-0.1485	(-0.2)	-0.1287	(-0.9)	Purpose = other

	CAR	TRAIN	LOCAL PT	Remarks
Categorical experiment interaction variables on vtt and vttr				
cf_sp2	0.5410 (12.1)	0.4998 (7.9)	0.5342 (7.2)	VTT in SP2A-experiment is 50-54% higher than in SP1A-experiment
Scale factors				
mu	-1.294 (-18.4)	-1.585 (-17.6)	-1.519 (-16.0)	General scale factor
sc_sp2	0.6523 (19.9)	0.6016 (12.5)	0.6250 (12.4)	Additional scale factor for SP2A-experiment
sc_cstsame	3.790 (13.5)	2.785 (7.7)	3.565 (7.5)	Add. scale factor for SP2A choice pairs with same cost levels
Continuous interaction variables on scale				
lmda_c_mu	-0.2365 (-4.7)	-0.2721 (-5.4)	-0.2596 (-4.0)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 5 EUR
lmda_t_mu	-0.8851 (-13.7)	-0.7302 (-8.6)	-0.7215 (-7.1)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min.
lmda_i_mu	-	-	-	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR.
cf_noinc_m	-	-	-	Interaction factor for respondents with unknown income level
Categorical interaction variables on scale				
cf_comm_mu	0 (*)	0 (*)	0 (*)	Purpose = commute (reference level)
cf_busi_mu	-0.4678 (-11.5)	-0.3293 (-3.4)	-0.4017 (-5.2)	Purpose = business. This and the following interaction factors are kept irrespective of their significance level since no a-prioir assumption can be made that these should be zero.
cf_wtp2_mu	0.3433 (1.9)	0.6849 (1.2)	0.5006 (1.4)	Purpose = business. Additional interaction for WTP-exp., group 2
cf_wtp4_mu	0.1215 (0.7)	-0.1127 (-0.3)	-1.213 (-0.8)	Purpose = business. Additional interaction for WTP-exp., group 4
cf_othr_mu	0.1046 (1.6)	0.1346 (1.6)	0.06529 (0.8)	Purpose = other
Legend				
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.			
0.6359 (7.8)	estimated coefficient with its t-ratio between brackets.			
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.			
x	coefficient is not tested			

Note that these conclusions only hold "if all else remains equal". Some of the attributes that are discussed are correlated with each other, so the overall effect in the population may be different (see for example the VTT dependency on BaseTime and on income in Section 12.2. From Table 15 we can conclude the following:

- `vtt_m, vtt_sigma:` The average value of travel time for a reference person (i.e. a person/trip-combination with all attributes at their reference level) is € 10.41 (car), € 11.54 (train) and € 8.89 (local public transport). This is the average of the lognormal distribution of the VTT (= $\exp(vtt\_m + vtt\_sigma^2 / 2)$. Note that no direct conclusions can be drawn from these values, since they strongly depend on the settings of the (arbitrary) reference levels. National average values for the VTT and VTTR are presented in Chapters 10 and 13.

- `rho:` The VTT and the VTTR are both randomly distributed in the population, each following a lognormal distribution. However, the VTT and VTTR are not independent: they are correlated with a correlation factor between 0.17 and 0.63.

- `lmda_c_vtt, lmda_t_vtt:` The VTT and VTTR depend strongly on the BaseCost (elasticity between 0.3 and 0.4), but they hardly depend on BaseTime (elasticity between -0.1 and 0.1, with very low t-ratios). However, the BaseCost and BaseTime values themselves are strongly correlated, so the VTT has a strong correlation with BaseTime, as was found in other studies.

- `lmda_i_vtt:` The VTT and VTTR depend on income: the higher the income, the higher the VTT/VTTR (elasticity between 0.06 and 0.20).

- `cf_purp2, cf_purp3:` The VTT and VTTR for business trips is typically 43% (car), 14% (train) and 33% (local public transport) higher than for commute trips. Note that additional interaction coefficients should be included for respondents that participated in the so-called "WTP-method" for the determination of the business VTT as will be discussed in Section 10.3 and is explained in detail in Appendix B. The VTT and VTTR for other trips (i.e. non-commute and non-business trips) is typically 12% lower (car), 18% lower (train) and 4% higher (local public transport). This last number might be surprising, but on average in the population (including all correlations) the VTT for purpose other for local public transport is lower than for commute, as will be shown in Section 10.1.

- `cf_frq`: Train and local public transport travellers making lower frequency trips have an up to 22% lower value for their VTT than travellers making higher frequency trips.
- `cf_gs_car`: Group size only has an (positive) impact on the VTT in car, and only for groups of 3 persons or more.
- `cf_peak`: Car and local public transport travellers travelling during peak hours have a 10% higher VTT than during off-peak.
- `cf_drctn`: The VTT for outward and return trips is not significantly different.
- `cf_male, cf_female`: The VTT does not depend significantly on gender.
- `cf_agecat`: Older travellers have an up to 33% lower VTT, depending on mode.
- `cf_edu`: Higher educated travellers have a higher VTT.
- `cf_wrksit`: Unemployed and student travellers in public transport have an approximately 25% lower VTT.
- `cf_zzp`: Self-employed car travellers have a 24% higher VTT while self employed train travellers have an 25% lower VTT.
- `cf_panel, cf_interce`: Train and local public transport respondents recruited at intercept locations do not have a significantly different VTT from respondent recruited from the internet panel. However, car intercept respondents have on average a 16% higher VTT. This is further discussed in Section 8.1.2.
- `cf_sp2`: The VTT estimated from SP2A is approximately 50% higher than the VTT estimated from SP1A. This is reviewed more closely in Section 8.1.3.
- `sc_cstsame`: The scale for the same-cost choice pairs in SP2A is larger than 1. This is expected since this is effectively a two-attribute experiment which is easier to answer for respondents, i.e. it is more deterministic. So the underlying random noise is smaller in this experiment. Since in the logit-estimations the coefficients are scaled with respect to this underlying noise, the scale coefficient in a two-attribute experiment is expected to be larger than in a three-attribute experiment, which results in a scale factor larger than 1.

8.1.2 Discussion on VTT difference between respondents recruited via intercept and internet panel

The VTT difference between respondents recruited via intercept and via an internet panel was an important finding from the 2009/2011 study. This was a decisive factor in the decision to include both intercept and internet panel respondents in the 2022 study. Therefore, for each mode, models[16] were estimated with and without an VTT interaction factor for being recruited via intercept. Table 16 shows the intercept interaction coefficient (with its t-ratio and the difference in log-likelihood between the model with and without this coefficient. Only for car the interaction coefficient is significant and hence the VTT for intercept and internet panel respondent is significantly different. Note that for walking no intercept recruitment was performed, so this test could not be executed for this mode. Also note that for car the interaction coefficient is about 0.23, while in Table 15 it has a value of 0.16. This is due to the fact that the latter was the result of a Mixed Logit model estimation based on SP1A and SP2A data, while the former is the result of an MNL model based on SP1A data only.

[16] MNL models with all significant interaction facors, estimated on SP1A data only.

Table 16 – Test on VTT difference between respondents recruited via intercept or via an internet panel

Mode	cf_intercept	Delta LL	
Car	0.2297 (3.9)	14.3	Significant
Train	-0.0451 (-0.7)	0.5	Not significant
Local PT	0.0943 (1.0)	0.9	Not significant
Air	0.0267 (0.6)	0.2	Not significant
Cycling	0.0211 (0.4)	0.4	Not significant
Walking	n.a.	-	
Recr.nav.	0.0812 (1.3)	0.9	Not significant

Result from 2009/2011 study

All respondents of the 2009 survey were members of the PanelClix internet panel. Research found a relatively low VTT. Therefore, in 2011 the survey was continued with recruitment via intercept only. In this 2011 survey, we asked respondents whether they were a member of an internet panel. The following table shows the VTT for three groups of respondents based on an estimation of an advanced MNL model.

Mode	Purpose	VTT (€ 2009) MEMBER OF PANELCLIX PANEL Value (T-ratio)	VTT (€ 2011) INTERNET MEMBER PANEL Value (T-ratio)	VTT (€ 2011) NO MEMBER OF PANEL Value (T-ratio)
Car/Train/Local PT	Commute	4.98 (34.0)	6.21 (16.1)	7.77 (28.7)
Car/Train/ Local PT	Business	4.59 (23.0)	6.05 (15.9)	6.95 (24.2)
Car/Train/ Local PT	Other	4.81 (20.7)	6.54 (12.5)	6.50 (20.4)

From this table, it can be concluded that (based on the 2009/2011 study):

- members of a general internet panel have a 13%-20% lower VTT than respondents that are not a member of such a panel, except for those travelling for other purposes;
- members of the PanelClix internet panel have an about 30% lower VTT than respondents that are not a member of an internet panel.

The PanelClix internet panel used in 2009 deviates from the Kantar NipoBase panel used for the 2022 study in a number of ways. For the Kantar panel, respondents cannot register themselves. Participation is only possible after an invitation by the panel manager, who ensures that the panel remains representative for the Dutch population. It is intensively managed: only members that regularly complete a survey are kept. In contrast, in principle everybody could register for the PanelClix internet panel in 2009 and the panel composition was not managed actively. Hence response rates were much lower which created serious risks for response biases.

To study this intercept recruitment effect for car in more detail, we repeated the estimation, but this time all car recruitment locations (see Table 4) were divided into six groups, and for each group a separate VTT interaction was estimated. The resulting estimates are shown in Table 17. The intercept location groups are sorted on their associated intercept interaction coefficients. The highest coefficient is found for the parking garages in Amsterdam (51% higher VTT compared to the internet panel). This also happens to be the most expensive location (parking in those garages costs approximately € 6.20 per hour). This might be a type of self selection: only people with a high VTT use expensive parking garages. But if such a self selection effect indeed occurred for car intercept recruitment in this study, it is likely it also affected the 2011 study where intercept recruitment was executed at similar locations. This needs to be considered when the results of this study are compared to those from the previous one.

Table 17 – Test on VTT difference between respondents recruited via intercept or via an internet panel for specific car recruitment sites

Mode	Intercept location	cf_intercept
Car	Parking place + fuel station A2 highway, 15 km south of Eindhoven	-0.07523 (-0.7)
	Parking garages, Zwolle (approx. € 3 / hr)	0.1392 (1.4)
	Parking place + fuel station A4 highway, 20 km south of Amsterdam	0.2244 (2.3)
	Parking place + (relative cheap unmanned) fuel station A27 highway, 30 km east of Amsterdam	0.2431 (2.3)
	Parking garages, The Hague (approx. € 3.30 / hr)	0.3217 (2.4)
	Parking garages, Amsterdam (approx. € 6.20 / hr)	0.5149 (3.8)

8.1.3 Discussion on VTT difference between SP1 and SP2

The cf_sp2 coefficient in Table 15 clearly implies that for car, train and local public transport the VTT estimated on SP2A data only is higher than the VTT estimated on SP1A data only. This coefficient has a value of approximately 0.5, indicating a roughly 50% higher VTT in SP2A compared to the reference VTT in SP1A. A similar value is found for the SP1A-air model (see Sections 8.2) and a slightly lower value is found for the SP1C-recreational navigation model (see Section 8.4). The values for cf_sp2 are summarised in Table 18.

Table 18 – VTT interaction coefficient of SP2 data compared to SP1 data

	cf_SP2	95% confidence interval
Car	0.54	0.45 - 0.63
Train	0.50	0.38 - 0.62
Bus, tram, metro	0.53	0.39 - 0.68
Air	0.56	0.44 - 0.68
Recr. navigation	0.26	0.14 - 0.38

These are not new findings and have been reported before, such as in the UK 2014-survey (ARUP et al. 2015, see Table 19 for the relevant results).

Table 19 - VTT interaction coefficient of SP2 data compared to SP1 data from the UK-2014 survey

	cf_SP2	95% confidence interval
Car	0.60	0.31 – 0.89
Rail	0.24	0.06 – 0.42
Bus	0.47	0.04 – 0.90
Other PT	0.12	-0.07 – 0.31

This result is also discussed in Hess et al. (2020). Their first hypothesis was that “the type of time being valued in [... SP1A ...] is representative of the conditions experienced by the respondent on the reference journey; i.e. if this journey was in heavy congestion, then the direct utility of the time component of the VTT off would relate to time spent in heavy congestion.” However, they tried to confirm this in their data, but they were not successful: they "did not find that the VTT was higher for respondents who had experienced "worse" conditions on their reference journey." They do not present any clear explanation for the difference, although in the conclusion section they suggest that "there is potentially increased reference dependence and non-linearity in data from simple time-money trade-offs."

On the other hand, these findings are not consistent with the findings from the previous Dutch VTT study in which no significant difference was found. In that study, respondents participated in three experiments:

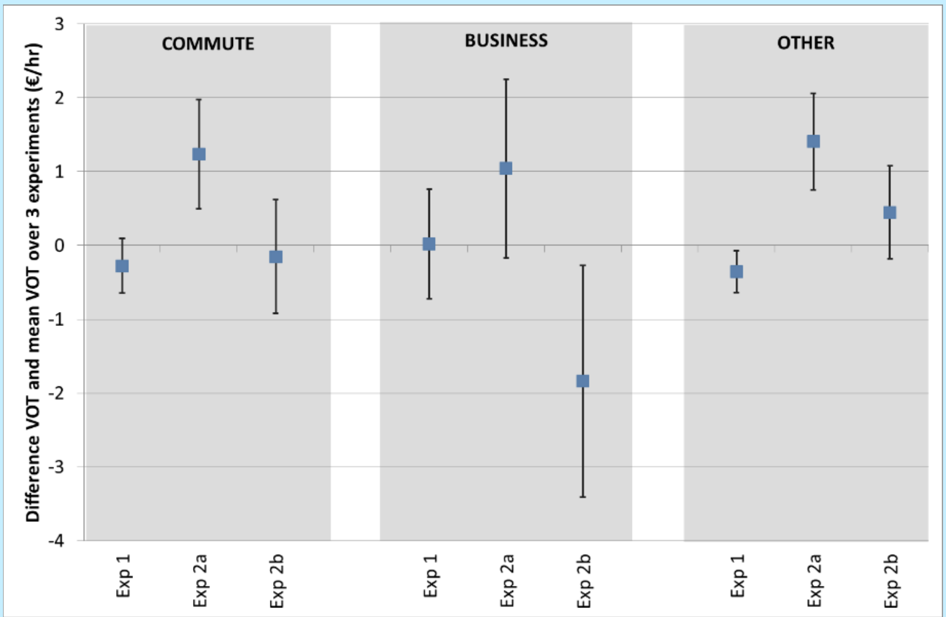
- Exp1: time/cost experiment similar to SP1 in the 2022-study
- Exp2a: time/cost/travel time reliability/departure time experiment: this resembles SP2A in the 2022-study, but in Exp2a the departure time and the common arrival time was also variable.
- Exp2b: time/cost/travel time reliability experiment: this experiment resembles SP2A more since the common arrival time is not variable.

In the 2009/2011 study, the absolute difference of the VTT (compared to the average over the three experiments) was checked (see figure below). No significant difference was found. However, it might be that there was confusion between the value of travel time and the value of travel time reliability which was introduced by the design of the 2009/2011 survey (for more information, see Section 13.2). So, it is difficult to draw any conclusion from this.

Result from 2009/2011 study

For the three surface mode segments (commute, business, other), a VTT was estimated for each of the three experiments (1, 2a and 2b) separately using a simple MNL model that also allowed for a reliability ratio. For each purpose, these VTTs were averaged (using the inverse variance of the estimated VTT as weight factor). The following figure shows the difference between the VTT of each experiment and the average VTT over the three experiments. Error bars indicated one standard deviation.

This figure shows that there is no significant difference between the three experiments (within 2 standard errors). It has been hypothesized that the VTT of experiment 1 would be larger than of experiment 2a and 2b, since in the latter two the value of reliability is estimated explicitly and in the former one it may be part of the VTT. However, as can be seen from the figure, there is no indication whatsoever that this hypothesis is true. There is no evidence that the VTT from experiment 1 contains any value of reliability.



The question remains which of the two VTT values should be used for the final calculation of the national average (i.e. from SP1 or from SP2). After ample discussion, we have decided to use the VTT from SP1. This is most consistent with previous Dutch studies from 1988, 1997 and 2009/2011, and is also consistent with international practice such as the UK-2014 survey where the same decision was made. However, we think this should be a topic for further (academic) investigation.

8.2 Joint SP1A/SP2A results for air + SP5A and SP6A results for airport access/egress

The estimates for the coefficient for the best models are displayed in Table 20. The utility function that was used for this estimation is similar to the one presented in Section 8.1.1.

Table 20 - Estimated coefficients for joint SP1A/2A model for air, SP5A model for airport access and SP6A model for airport egress

	AIR FLIGHT	AIR ACCESS	AIR EGRESS	Remarks
Observations	15872	3627	797	
Final log (L)	-5720.9	-1971.3	-304.1	
D.O.F.	30	25	15	
Rho²(0)	0.48	0.216	0.45	
Reference value of travel time				
vtt_m	3.837 (49.5)	3.837 (*)	3.837 (*)	Mean and standard deviation of the distribution of ln(vtt) which
vtt_sigma	0.6404 (21.4)	0.6404 (*)	0.6404 (*)	applies to a respondent with all variables at their reference level
Reference value of travel time reliability				
vttr_m	1.806 (12.9)	x	x	Mean and standard deviation of the distribution of ln(vttr) which
vttr_sigma	1.397 (22.6)	x	x	applies to a respondent with all variables at their reference level
rho	0.4543 (7.7)	x	x	Correlation coefficient of the randomly distributed vtt and vttr
Continuous interaction variables on vtt				
lmda_c_vtt	0.4416 (12.5)	0.4416 (*)	0.4416 (*)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 300 EUR for air travel and 5 EUR for all other modes. Higher travel costs imply a higher vtt
lmda_t_vtt	-0.1124 (-2.8)	-0.1124 (*)	-0.1124 (*)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 300 min. for air travel. Higher travel times seem to imply a lower vtt (air) or constant vtt (other modes). However, higher travel times are strongly correlated with higher travel costs, so that overall respondents with higher travel times will have a higher vtt (as expected based on other studies).
lmda_i_vtt	0.1080 (1.9)	0.1080 (*)	0.1080 (*)	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR. Income refers to yearly household income before taxes.
cf_noinc	-0.04770 (-0.6)	-0.04770 (*)	-0.04770 (*)	Interaction factor for respondents with unknown income level. This coefficient is kept irrespective of its significance level if any other education interaction coefficient is estimated, to prevent bias on the reference level.
Categorical trip interaction variables on vtt				
cf_purp2	0.1939 (2.3)	0.1939 (*)	0.1939 (*)	Purpose = business
cf_wtp2_vt	3.742 (1.8)	3.742 (*)	3.742 (*)	Purpose = business. Additional interaction for WTP-experiment, group 2
cf_wtp4_vt	4.429 (1.4)	4.429 (*)	4.429 (*)	Purpose = business. Additional interaction for WTP-experiment, group 4
cf_purp1	x	x	x	Purpose = commute (reference level for all modes except air (for which no commute trips are observed))
cf_purp3	0 (*)	0 (*)	0 (*)	Purpose = other (reference level).
cf_frq1	0 (*)	0 (*)	0 (*)	Frequency = one-time trip (reference level)
cf_frq2	-	x	x	Frequency = less than once per year
cf_frq3	-	x	x	Frequency = once/several times per year
cf_frq4	-	x	x	Frequency = once/several times per month. Constrained to 0. Was significant, but was only based on 12 respondents. Not sufficiently substantiated.
cf_frq5	-	x	x	Frequency = once/several times per week
cf_gs_1	0 (*)	0 (*)	0 (*)	Group size = 1 person (reference level)
cf_gs_oth2	0.1129 (2.2)	0.1129 (*)	0.1129 (*)	Group size = 2 persons or more. Not tested for car. Only significantly different from the reference level for air.
cf_dirctn1	0 (*)	0 (*)	0 (*)	Direction = outward trip
cf_dirctn2	-	x	x	Direction = return trip. Never signficanlty different from cf_dirctn1
cf_dirctn3	-	x	x	Direction = other (i.e. non-home based trip).
cf_vtt_cpf	x	-0.7808 (-13.1)	-0.7214 (-19.8)	Mode = car park & fly (SP5A/6A only)

	AIR FLIGHT	AIR ACCESS	AIR EGRESS	Remarks
cf_vtt_ckf	x	-0.8160 (-13.5)	-0.7060 (-15.5)	Mode = car kiss & fly (SP5A/6A only)
cf_vtt_pt	x	-0.8905 (-35.2)	-0.7554 (-29.4)	Mode = train or train+bus (SP5A/6A only)
cf_vtt_tax	x	-0.8775 (-23.6)	-0.5435 (-3.9)	Mode = taxi (SP5A/6A only)
dum_airp_1	x	0 (*)	x	Additional time at airport = 5 minutes (reference level)
dum_airp_2	x	-2.419 (-4.5)	x	Additional time at airport = 30 minutes
dum_airp_3	x	-3.933 (-4.8)	x	Additional time at airport = 60 minutes
dum_airp_4	x	-5.821 (-5.1)	x	Additional time at airport = 90 minutes
dum_airp_5	x	-4.710 (-5.4)	x	Additional time at airport = 120 minutes
dum_airp_6	x	-4.083 (-5.2)	x	Additional time at airport = 150 minutes
dum_airp_7	x	-3.149 (-5.3)	x	Additional time at airport = 180 minutes
dum_pmis_1	x	0 (*)	x	Probability of missing flight = 1 in 1000 (reference level)
dum_pmis_2	x	0.3420 (1.1)	x	Probability of missing flight = 1 in 500
dum_pmis_3	x	0.9551 (2.2)	x	Probability of missing flight = 1 in 200
dum_pmis_4	x	1.761 (3.0)	x	Probability of missing flight = 1 in 100
dum_pmis_5	x	3.163 (4.3)	x	Probability of missing flight = 1 in 50
Categorical personal interaction variables on vtt				
cf_male	-	x	x	Gender = male (reference level)
cf_female	-	x	x	Gender = female. Not significantly different from cf_male for any mode.
cf_agecat1	0 (*)	0 (*)	0 (*)	Age = 16-35 (reference level)
cf_agecat2	0.09879 (1.7)	0.09879 (*)	0.09879 (*)	Age = 36-50
cf_agecat3				Age = 51-65
cf_agecat4	-	x	x	Age = 66+
cf_edu1	-	x	x	Education level = LO/MAVO/VBO/VMBO/LBO
cf_edu2	-	x	x	Education level = MBO. Constrained to zero for air because of an implausible value.
cf_edu34	0 (*)	0 (*)	0 (*)	Education level = HAVO/VWO/HBO/WO (reference level). Level 3 (HAVO/VWO) had an implausible value for train and was not significantly different from level 4 (HBO/WO) for any other mode.
cf_edu5	-	x	x	Education level = Other. This coefficient is kept irrespective of its significance level if any other education interaction coefficient is estimated, to prevent bias on the reference level.
cf_hhsiz12	0 (*)	0 (*)	0 (*)	Household size = 1 or 2 persons (reference level). Level 1 (1 persons) was not significantly different from level 2 (2 persons) for any mode.
cf_hhsiz34	-	x	x	Household size = 3 or more persons. Level 3 (3 persons) was tested separately from level 4 (4 persons or more) but these levels were not significantly different for any mode.
cf_wrksit1	0 (*)	0 (*)	0 (*)	Work situation = employed (reference level)
cf_wrksit2	0.1948 (1.7)	0.1948 (*)	0.1948 (*)	Work situation = unemployed
cf_wrksit3	-0.3812 (-4.8)	-0.3812 (*)	-0.3812 (*)	Work situation = student. Constrained to 0 for car because of an implausible value
cf_wrksit4	0.3002 (2.7)	0.3002 (*)	0.3002 (*)	Work situation = retired
cf_wrksit5	0.06284 (0.5)	0.06284 (*)	0.06284 (*)	Work situation = other. This coefficient is kept irrespective of its significance level if any other work situation interaction coefficient is estimated, to prevent bias on the reference level.
cf_nozzp	0 (*)	0 (*)	0 (*)	ZZP-type = no
cf_zzp	-	x	x	ZZP-type = yes (self-employed)
cf_panel	0 (*)	0 (*)	0 (*)	Recruitment type = panel (reference level)
cf_interce	-	x	x	Recruitment type = intercept. Only for car this interaction factor was significantly different from 0.
Categorical trip interaction variables on vttr				
cf_vttrpurp2	0.05465 (0.3)	x	x	Purpose = business
cf_vttrpurp3	0 (*)	x	x	Purpose = other (reference level).
Categorical experiment interaction variables on vtt				
cf_sp2	0.5560 (9.1)	x	x	VTT in SP2A-experiment is 50-54% higher than in SP1A-experiment
Scale factors				
mu	-0.06633 (-18.4)	-0.02369 (-4.4)	-0.3936 (-5.2)	General scale factor
sc_sp2	0.5957 (12.3)	x	x	Additional scale factor for SP2A-experiment
sc_cstsame	2.720 (8.3)	x	x	Additional scale factor for choice pairs in SP2A with same cost levels
Continuous interaction variables on scale				
lmda_c_mu	-0.3498 (-7.0)	-0.5108 (-8.5)	-0.4095 (-2.9)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 300 EUR for air travel and 5 EUR for all other modes.
lmda_t_mu	-0.7438 (-13.3)	0.4418 (5.2)	-0.8624 (-5.5)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 300 min. for air travel and 60 min. for all other modes.

	AIR FLIGHT		AIR ACCESS		AIR EGRESS		Remarks
lmda_i_mu	0.1819	(3.5)	-0.2713	(-4.7)	0.2443	(2.3)	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR.
cf_noinc_m	-0.1584	(-2.0)	0.1279	(1.0)	0.4609	(1.2)	Interaction factor for respondents with unknown income level
Categorical interaction variables on scale							
cf_busi_mu	-0.4980	(-10.1)	x		x		Purpose = business (SP1A/2A only)
cf_mu_bss	x		-0.3068	(-3.8)	-0.2657	(-1.7)	Purpose = business (SP5A/6A only)
cf_wtp2_mu	-0.05319	(-0.4)	1.290	(2.1)	1.052	(0.9)	Purpose = business. Additional interaction for WTP-experiment, group 2
cf_wtp4_mu	0.1900	(0.8)	2.163	(2.4)	0.8641	(0.6)	Purpose = business. Additional interaction for WTP-experiment, group 4
cf_othr_mu	0	(*)	0	(*)	0	(*)	Purpose = other (reference level)
cf_mu_cpf	x		0	(*)	0	(*)	Mode = car park & fly (reference level for SP5A/6A)
cf_mu_ckf	x		0.3883	(0.8)	0.1898	(0.6)	Mode = car kiss & fly (SP5A/6A only)
cf_mu_pt	x		1.035	(1.9)	0.2825	(0.9)	Mode = public transport (SP5A/6A only)
cf_mu_tax	x		1.057	(1.4)	-0.7526	(-8.4)	Mode = taxi (SP5A/6A only)
Legend							
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.						
0.4416 (12.6)	estimated coefficient with its t-ratio between brackets.						
0.4416 (*)	coefficient is not estimated, but constrained to this value (taken from SP1A/2A model)						
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.						
x	coefficient is not tested						

From this table, we can conclude the following. Note that these conclusions only hold "if all else remains equal".

- `vtt_m, vtt_sigma:` The average value of travel time for a reference person (i.e. a person/trip-combination with all attributes at their reference level) is € 56.94 for the time spent flying on an air trip. This is the average of the lognormal distribution of the VTT. Note that no direct conclusions can be drawn from these values, since they strongly depend on the settings of the (arbitrary) reference levels. National average values for the VTT and VTTR are presented in Chapters 11.1 and 13.
- `rho:` The VTT and the VTTR for the in-flight component of an air trip are both randomly distributed in the population, each following a lognormal distribution. However, the VTT and VTTR are not independent: they are correlated with a correlation factor between 0.45.
- `lmda_c_vtt, lmda_t_vtt:` The VTT and VTTR for the in-flight component of an air trip depend more strongly the BaseCost (elasticity 0.44), but they negatively depend on BaseTime (elasticity between -0.11). However, the BaseCost and BaseTime values themselves are strongly correlated, so the VTT has a strong correlation with BaseTime, as was found in other studies.
- `lmda_i_vtt:` The VTT and VTTR depend on income: the higher the income, the higher the VTT/VTTR (elasticity = 0.11).
- `cf_purp2:` The VTT and VTTR for business trips is typically 19% higher than for non-business (i.e. other purposes).
- `cf_frq:` No significant relation between the VTT and the frequency of making this flight was `cf_:` discovered.
- `cf_gs:` The VTT and VTTR are 11% higher when flying with a group of 2 persons or more.
- `cf_age, cf_gender, cf_edu, cf_wrksit, cf_dirctn:` No significant interactions were found for other trip and personal characteristics (age, gender, education, work status, direction of the trip).
- `cf_vtt_cpf, cf_vtt_ckf, cf_vtt_pt, cf_vtt_tax:` The VTT for airport access is between 78% and 89% lower than the VTT for the in-flight component of the air trip, depending on the mode used for the access trip.
- `cf_vtt_cpf, cf_vtt_ckf, cf_vtt_pt, cf_vtt_tax:` The VTT for airport egress is between 54% and 76% lower than the VTT for the in-flight component of the air trip, depending on the mode used for

the egress trip. For airport egress, the VTT is higher than for airport access. This finding is further discussed in Section 11.1.2.

8.3 SP1B results for cycling and walking

The estimates for the coefficient for the best models are displayed in Table 21. The utility function that was used for this estimation is similar to the one presented in Section 8.1.1.

Table 21 - Estimated coefficients for SP1B models for cycling and walking

	CYCLING		WALKING		Remarks
Observations	7632		4840		
Final log (L)	-2527.2		-1484.3		
D.O.F.	22		24		
Rho²(0)	0.522		0.558		
Reference value of travel time					
vtt_m	1.820	(17.7)	2.411	(9.5)	Mean and standard deviation of the distribution of ln(vtt) which
vtt_sigma	0.8492	(15.5)	0.6177	(5.4)	applies to a respondent with all variables at their reference level
Continuous interaction variables on vtt and vttr					
lmda_t_vtt			-0.6344	(-5.6)	VTT cycle/walk elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 30 min.
lmda_t_vEb	-0.2580	(-5.5)	-0.5219	(-2.5)	VTT rental e-bike elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 30 min.
lmda_t_vCa			0	(*)	VTT car elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 30 min.
lmda_i_vtt	-		-0.02602	(-0.6)	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR. Income refers to yearly household income before taxes.
cf_noinc	-		-0.01354	(-0.1)	Interaction factor for respondents with unknown income level.
Categorical trip interaction variables on vtt and vttr					
cf_cycling	0	(*)	x		Mode = cycling (reference level)
cf_walking	x		0	(*)	Mode = walking (reference level)
cf_car	-0.1818	(-1.3)	-0.8884	(-3.0)	Mode = car
cf_ebk	-0.4148	(-8.7)	-0.6676	(-4.1)	Mode = rental e-bike
cf_purp1	0	(*)	0	(*)	Purpose = commute (reference level)
cf_purp2	0.2187	(1.8)	0.08993	(1.1)	Purpose = business.
cf_purp3	0.1635	(1.9)	-0.01046	(-0.2)	Purpose = other
cf_frq1	-		0.5428	(2.2)	Frequency = one-time trip
cf_frq2	-		0.4660	(3.2)	Frequency = once/several times per year
cf_frq3	-		0.2295	(2.5)	Frequency = once/several times per month
cf_frq4	-		-		Frequency = 1-2 times per week
cf_frq5	0	(*)	0	(*)	Frequency = 3-4 times per week (reference level)
cf_frq6	-		-		Frequency = 5 or more times per week
cf_offpeak	0	(*)	0	(*)	Period of the day = off peak (reference)
cf_peak	-		-		Period of the day = peak. This means that the midpoint of the trip falls between 7:00 and 9:00 or between 16:00 and 18:00. Not tested for air travel. cf_peak is significant for bus/tram/metro despite low t-ratio.
cf_dirctn1	0	(*)	0	(*)	Direction = outward trip
cf_dirctn2	-		-		Direction = return trip. Never signficanlty different from cf_dirctn1
cf_dirctn3	-		-		Direction = other (i.e. non-home based trip).
Categorical personal interaction variables on vtt and vttr					
cf_male	-		-		Gender = male (reference level)
cf_female	-		-		Gender = female.
cf_agecat1	0	(*)	0	(*)	Age = 16-35 (reference level)
cf_agecat2	-0.1026	(-1.5)	-0.1507	(-2.3)	Age = 36-50
cf_agecat3	-0.1509	(-2.3)	-0.3183	(-4.8)	Age = 51-65
cf_agecat4	-		-0.3846	(-4.8)	Age = 66+.
cf_edu1	-		-		Education level = LO/MAVO/VBO/VMBO/LBO
cf_edu2	-		-		Education level = MBO.
cf_edu3	-		-0.08545	(-1.1)	Education level = HAVO/VWO
cf_edu4	0	(*)	0	(*)	Education level = HBO/WO (reference level)
cf_edu5	-		0.9053	(3.5)	Education level = Other
cf_hhsize1	0	(*)	0	(*)	Household size = 1 person (reference level)
cf_hhsize2	0.2740	(2.7)	-		Household size = 2 persons

	CYCLING	WALKING	Remarks
cf_hhsize3		0.2007 (2.5)	Household size = 3 persons
cf_hhsize4			Household size = 4 persons or more
cf_wrksit1	0 (*)	0 (*)	Work situation = employed (reference level)
cf_wrksit2	-	-	Work situation = unemployed
cf_wrksit3	-	-	Work situation = student
cf_wrksit4	-0.3236 (-3.9)	-	Work situation = retired
cf_wrksit5	0.03866 (0.1)	-	Work situation = other
cf_nozzp	0 (*)	0 (*)	ZZP-type = no
cf_zzp	-0.3480 (-3.7)	-	ZZP-type = yes (self-employed)
cf_panel	0 (*)	0 (*)	Recruitment type = panel (reference level)
cf_interce	-	x	Recruitment type = intercept
Scale factors			
mu_car	-0.8081 (-6.1)	-0.6438 (-7.8)	General scale factor for experiment with car as alternative
mu_ebk	-1.484 (-11.7)	-0.7605 (-5.5)	General scale factor for experiment with rental e-bike as alternative
Continuous interaction variables on scale			
lmda_t_mu	-0.5417 (-6.2)	-0.7384 (-6.0)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min.
lmda_i_mu	-0.06426 (-0.9)	0	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR.
cf_noinc_mu	-0.1008 (-1.0)	0	Interaction factor for respondents with unknown income level
Categorical interaction variables on scale			
cf_comm_mu	0 (*)	0 (*)	Purpose = commute (reference level)
cf_busi_mu	0.03359 (0.3)	0	Purpose = business
cf_othr_mu	-0.1523 (-1.9)	0	Purpose = other
Alternative specific constants			
asc_cycling	0 (*)	x	Mode = cycling (reference level)
asc_walking	x	0 (*)	Mode = walking (reference level)
asc_car	3.581 (6.6)	6.418 (4.3)	Mode = car
asc_ebk	2.514 (10.7)	7.270 (3.3)	Mode = rental e-bike

Legend	
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.
0.6359 (7.8)	estimated coefficient with its t-ratio between brackets.
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.
x	coefficient is not tested

From this table, we can conclude the following. Note that these conclusions only hold "if all else remains equal".

- `vtt_m, vtt_sigma`: The average value of travel time for a reference person (i.e. a person/trip-combination with all attributes at their reference level) is € 8.85 (cycling) and € 13.49 (walking). This is the average of the lognormal distribution of the VTT. Note that no direct conclusions can be drawn from these values, since they strongly depend on the settings of the (arbitrary) reference levels. National average values for the VTT are presented in Section 11.2.
- `lmda_t_vtt, lmda_t_vEb, lmda_t_vCa`: The VTT depends on BaseTime (elasticity between 0.25 for cycling and 0.63 for walking). The walking model also allows the VTT for the alternative modes to have a different BaseTime elasticity.
- `cf_car, cf_ebk`: The VTT of the alternative modes is lower than for cycling / walking.
  - For car: 18% lower for the cycling experiment and 89% lower for the walking experiment
  - For rental e-bike: 41% lower for the cycling experiment and 67% lower for the walking experiment.

  Note that for the walking experiment these percentages only apply for a trip with BaseTime = 30 minutes due to the difference of the BaseTime elasticity between the modes. Nevertheless, these percentages may seem quite large. However, there is a strong correlation between these percentages and the values for the alternative specific constants. The modelling effort has concentrated on identifying the VTT for cycling and walking and not so much for the alternative modes. Therefore, not much interpretation should be given to the VTT values for these alternative modes (also because they are determined based on a specific group of respondents that is currently cycling or walking). Furthermore, this experiment should not be used to determine the VTT for rental e-bikes (or for the VTT difference between bike and a rental e-bike).

- `cf_purp:` The VTT and VTTR for business trips is typically between 8% and 22% higher than for commute trips. For other trips, the difference is between 16% higher and 1% lower. However, this finding will be different if all correlations are considered. Furthermore, the low t-ratios of these coefficients should also be comtemplated when interpreting these results.
- `cf_agecat:` Cyclists between 36 and 65 years of age have a 10-15% lower VTT than younger or older cyclists. Walkers above 36 years of age have a 15-38% lower VTT than walkers younger than 36 years.
- `cf_edu:` Education only has a very small effect on the VTT for walking (9% lower for education level HAVO/VWO compared to other education levels) and has no significant effect on the VTT for cycling.
- `cf_hhsize:` Cyclist/walkers living in larger households have a 20-27% higher VTT compared to those living alone.
- `cf_wrksit:` Retired cyclists have a 32% lower VTT than those who are not retired. Self-employed cyclists have a 35% lower VTT than those who are employed.

8.4 Joint SP1C/SP2C results for recreational navigation

The estimates for the coefficient for the best models are displayed in Table 22. The utility function that was used for this estimation is similar to the one presented in Section 8.1.1.

Table 22 - Estimated coefficients for joint SP1C/2C model for recreational navigation

	RECR.NAV.	Remarks
Observations	4024	
Final log (L)	-1519.0	
D.O.F.	11	
Rho²(0)	0.455	
Reference value of waiting time for bridge/lock		
vtt_m	2.024 (11.3)	Mean and standard deviation of the distribution of ln(vtt) which
vtt_sigma	0.8756 (14.5)	applies to a respondent with all variables at their reference level
Reference value of waiting time reliability		
vttr_m	-	Mean and standard deviation of the distribution of ln(vttr) which
vttr_sigma	-	applies to a respondent with all variables at their reference level
Continuous interaction variables on vtt and vttr		
lmda_i_vtt	0.1860 (1.8)	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR. Income refers to yearly household income before taxes.
cf_noinc	-0.2968 (-2.5)	Interaction factor for respondents with unknown income level
Categorical trip interaction variables on vtt and vttr		
cf_frq1	-	Frequency = one-time trip
cf_frq2	-	Frequency = once/several times per year
cf_frq3	-	Frequency = once/several times per month
cf_frq4	-	Frequency = 1-2 times per week
cf_frq5	0 (*)	Frequency = 3-4 times per week (reference level)
cf_frq6	-	Frequency = 5 or more times per week
cf_gs_1	0 (*)	Group size = 1 person (reference level)
cf_gs_2	0.5269 (2.4)	Group size = 2 persons
cf_gs_3pl	0.5681 (2.3)	Group size = 3 persons or more.
Categorical personal interaction variables on vtt and vttr		
cf_male	-	Gender = male (reference level)
cf_female	-	Gender = female. Not significantly different from cf_male for any mode.
cf_agecat1	0 (*)	Age = 16-35 (reference level)
cf_agecat2	-	Age = 36-50

	RECR.NAV.	Remarks
cf_agecat3	-	Age = 51-65
cf_agecat4	-	Age = 66+.
cf_edu1	-	Education level = LO/MAVO/VBO/VMBO/LBO
cf_edu2	-	Education level = MBO.
cf_edu34	0 (*)	Education level = HAVO/VWO/HBO/WO (reference level)
cf_edu5	-	Education level = Other
cf_hhsize1	0 (*)	Household size = 1 person (reference level)
cf_hhsize2	0.5269 (2.4)	Household size = 2 persons
cf_hhsiz34	-0.3513 (-2.7)	Household size = 3 or more persons.
cf_wrksit1	0 (*)	Work situation = employed (reference level)
cf_wrksit2	-	Work situation = unemployed
cf_wrksit3	-	Work situation = student
cf_wrksit4	-	Work situation = retired
cf_wrksit5	-	Work situation = other
cf_nozzp	0 (*)	ZZP-type = no
cf_zzp	-	ZZP-type = yes (self-employed)
cf_panel	0 (*)	Recruitment type = panel (reference level)
cf_interce	-	Recruitment type = intercept. Only for car this interaction factor was significantly different from 0.
Categorical experiment interaction variables on vtt and vttr		
cf_sp2	0.2620 (4.2)	VTT in SP2A-experiment is 50-54% higher than in SP1A-experiment
Scale factors		
mu	-0.8070 (-15.3)	General scale factor
sc_sp2	0.8313 (10.8)	Additional scale factor for SP2A-experiment
Continuous interaction variables on scale		
lmda_i_mu	-	Elasticity of ratio Income/Income0 with Income0 = 70000 EUR.
cf_noinc_m	-	Interaction factor for respondents with unknown income level
Legend		
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.	
0.6359 (7.8)	estimated coefficient with its t-ratio between brackets.	
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.	
x	coefficient is not tested	

From this table, we can conclude the following. Note that these conclusions only hold "if all else remains equal".

- `vtt_m, vtt_sigma:` The average value of waiting time for a reference person (i.e. a person/trip-combination with all attributes at their reference level) is € 11.10. This is the average of the lognormal distribution of the VTT.[17] Note that no direct conclusions can be drawn from these values, since they strongly depend on the settings of the (arbitrary) reference levels. National average values for the VTT and VTTR are presented in Section 11.3 and Chapter 13.
- `lmda_i_vtt:` The VTT and VTTR depend on income: the higher the income, the higher the VTT/VTTR (elasticity = 0.19).
- `cf_frq:` No significant relation between the VTT and the frequency of making this trip was discovered.
- `cf_gs:` The VTT is up to 56% higher when making this trip with a group.
- `cf_hhsize:` The VTT is up to 53% higher when the respondent is from a 2-person household, while it is 35% lower for a respondent from a larger household.

Note that the coefficients related to the reliability (`vttr_m, vttr_sigma`) turned out to be not significantly different from zero, indicating that the reliability ratio is not significantly different from zero.

[17] For consistency with other modes, the abbreviation VTT is used, while the value of waiting time for a bridge or lock is meant.

8.5 SP2B results for cycling and walking on travel time comfort

The estimates for the coefficient for the best models are displayed in Table 23.

Table 23 - Estimated coefficients for SP2B model for cycling and walking

	CYCLING	WALKING	Remarks
Observations	8256	5352	
Final log (L)	-4350.6	-2583.4	
D.O.F.	21	21	
Rho²(0)	0.24	0.304	
Time coefficient			
b_time	-2.707 (-15.9)	-2.006 (-13.7)	Time coefficient
Continuous interaction variables on vtt and vttr			
lambda_t	-1.064 (-20.2)	-1.265 (-25.6)	time coeff. elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min.
Categorical interaction variables on path type			
dum_path_1	0.08505 (4.6)	0.3969 (10.6)	Path type = level 1
dum_path_2	0.2330 (16.6)	0.5985 (12.1)	Path type = level 2
dum_path_3	-0.04425 (-2.8)	0.1003 (4.8)	Path type = level 3
dum_path_4	-0.00656 (-0.4)	(#)	Path type = level 4
dum_path_5	0.03445 (2.1)	0.00458 (0.2)	Path type = level 5
dum_path_6	(#)	0.03448 (1.8)	Path type = level 6
dum_path_7	0.1225 (7.3)	-0.1816 (-7.6)	Path type = level 7
dum_path_8	-0.1384 (-11.5)	-0.1682 (-7.7)	Path type = level 8
Categorical interaction variables on pavement type			
dum_pave_1	0.1832 (12.3)	0.07178 (3.3)	Pavement (cycling) or path width type (walking) = level 1
dum_pave_2	0.1692 (11.4)	0.00790 (0.4)	Pavement (cycling) or path width type (walking) = level 2
dum_pave_3	0.08535 (6.4)	(#)	Pavement (cycling) or path width type (walking) = level 3
dum_pave_4	(#)	-0.04750 (-2.0)	Pavement (cycling) or path width type (walking) = level 4
Categorical interaction variables on route beautifulness type			
dum_rout_1	-0.06831 (-6.9)	-0.06782 (-4.4)	Route beautifulness type = level 1: very beautiful
dum_rout_2	-0.05116 (-10.2)	-0.05345 (-6.4)	Route beautifulness type = level 2: beautiful
dum_rout_3	(#)	(#)	Route beautifulness type = level 3: not beautiful
dum_rout_4	0.2851 (20.2)	0.3737 (13.2)	Route beautifulness type = level 4: absolutely not beautiful
Categorical interaction variables on number of cars (interacted with path type)			
dum_p15_c1	-0.05578 (-4.3)	x	Number of cars = level 1: very few, for path type = 1-5 (cycling)
dum_p15_c2	-0.04432 (-7.3)	x	Number of cars = level 2: few, for path type = 1-5 (cycling)
dum_p15_c3	(#)	x	Number of cars = level 3: many, for path type = 1-5 (cycling)
dum_p15_c4	0.2644 (14.9)	x	Number of cars = level 4: very many, for path type = 1-5 (cycling)
dum_p67_c1	-0.06574 (-2.9)	x	Number of cars = level 1: very few, for path type = 6-7 (cycling)
dum_p67_c2	-0.03657 (-2.3)	x	Number of cars = level 2: few, for path type = 6-7 (cycling)
dum_p67_c3	(#)	x	Number of cars = level 3: many, for path type = 6-7 (cycling)
dum_p67_c4	0.1493 (4.4)	x	Number of cars = level 4: very many, for path type = 6-7 (cycling)
dum_p12_c1	x	-0.1549 (-5.1)	Number of cars = level 1: very few, for path type = 1-2 (walking)
dum_p12_c2	x	-0.06319 (-4.2)	Number of cars = level 2: few, for path type = 1-2 (walking)
dum_p12_c3	x	(#)	Number of cars = level 3: many, for path type = 1-2 (walking)
dum_p12_c4	x	0.08026 (2.2)	Number of cars = level 4: very many, for path type = 1-2 (walking)
dum_p36_c1	x	-0.08576 (-4.6)	Number of cars = level 1: very few, for path type = 3-6 (walking)
dum_p36_c2	x	-0.06296 (-4.5)	Number of cars = level 2: few, for path type = 3-6 (walking)
dum_p36_c3	x	(#)	Number of cars = level 3: many, for path type = 3-6 (walking)
dum_p36_c4	x	0.2109 (7.6)	Number of cars = level 4: very many, for path type = 3-6 (walking)

Legend	
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.
0.6359 (7.8)	estimated coefficient with its t-ratio between brackets.
(#)	Coefficient is a linear combination of the coefficients of all other levels, such that their (weighted) average equals 0
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.
x	coefficient is not tested

Since the resulting coefficients are directly related to the multipliers that are the final objective of this modelling effort, the discussion on their values is postponed until Chapter 14.

8.6 SP3A and SP4A results for train and local public transport on trip components and on crowding

The estimates for the coefficient for the best models are displayed in Table 24.

Table 24 - Estimated coefficients for SP3A and SP4A models for train and local public transport

	TRAIN	LOCAL PT	TRAIN	LOCAL PT	Remarks
Observations	3056	3200	3232	3216	
Final log (L)	-1324	-1372.1	-1472	-1516	
D.O.F.	11	10	10	12	
Rho²(0)	0.375	0.381	0.343	0.32	
Reference value of travel time					
vtt	8.336 (15.2)	6.165 (14.7)	5.944 (16.3)	6.120 (14.8)	Value of travel time
Continuous interaction variables on vtt and vttr					
lmda_c_vtt	0.2531 (3.7)	0.5685 (6.3)	0.5411 (6.8)	0.4332 (4.7)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 5 EUR. Higher travel costs imply a higher vtt
lmda_t_vtt	-0.2001 (-1.6)	-0.5046 (-3.3)	-0.01893 (-0.2)	0.2004 (1.1)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min. This coefficient is kept irrespective of its significance level due its importance for this study.
Categorical trip interaction variables on vtt and vttr					
cf_purp1	0 (*)	0 (*)	0 (*)	0 (*)	Purpose = commute (reference level)
cf_purp2	0.5119 (2.5)	-	-	0.7376 (2.3)	Purpose = business
cf_purp3	-	-	-	-	Purpose = other
Multipliers for trip components					
fac_aetm	1.110 (9.2)	1.035 (6.2)	x	x	Total access + egress time
fac_wttm	0.9542 (7.4)	0.7198 (4.0)	x	x	Total wait and transfer time
fac_ntrf	11.30 (12.2)	12.24 (10.8)	x	x	Number of transfers
Multipliers for crowding					
crwd_13	x	x	0 (*)	0 (*)	Additional multiplier for crowding levels 1-5
crwd_4pl	x	x	0.1773 (7.1)	0.04109 (3.0)	Additional multiplier for each crowding level above 4
dum_sest_2	x	x	0.7557 (9.1)	0.1234 (2.8)	Additional multiplier if person has to stand
crwd_4p_s2	x	x	-	0.1101 (3.5)	Additional multiplier for each crowding level above 4 and person has to stand
Multiplier for frequency					
fac_intt	x	x	0.4570 (5.1)	x	Multiplier for headway time (= 1 / frequency, in hours)
fac_inttl	x	x	x	0.1251 (4.1)	Multiplier for (natural) logarithm of headway time (= 1 / frequency, in hours)
Scale factors					
mu_cost	-1.060 (-11.1)	-0.8661 (-12.5)	-1.214 (-12.0)	-1.037 (-10.1)	General scale factor
scalesp3a	-0.3848 (-6.3)	-0.3927 (-6.4)	x	x	Additional scale factor for SP3A-experiment (difference from 1)
scalesp4a	x	x	-0.6458 (-14.4)	-0.6394 (-14.5)	Additional scale factor for SP4A-experiment (difference from 1)
Continuous interaction variables on scale					
lmda_c_mu	-0.3396 (-4.5)	-0.3379 (-3.9)	-0.5365 (-4.8)	-0.3616 (-3.1)	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 5 EUR
lmda_t_mu	-0.7042 (-4.5)	-0.9702 (-6.5)	-0.5369 (-3.2)	-0.6171 (-3.5)	Elasticity of ratio BaseTime/BaseTime0 with BaseTime0 = 60 min.

Legend	
0 (*)	coefficient is used as the reference level, so it is constrained to zero by default. The estimated values for vtt or mu apply to this level.
0.6359 (7.8)	estimated coefficient with its t-ratio between brackets.
-	coefficient is tested, but was not significantly different from zero at a 95% significance level, or had an implausible value and was constrained to zero.
x	coefficient is not tested

Since the resulting coefficients are directly related to the multipliers that are the final objective of this modelling effort, the discussion on their values is postponed until Chapter 14.

9. Sample enumeration

Sample enumeration is necessary to determine the national average of the VTT since the survey may not be fully representative for the full set of trips made in the Netherlands (despite our efforts to get a representative sample). In a sample enumeration weights can be applied to each respondent such that the weighted sample becomes representative. It is not necessary to determine the national average of a multiplier such as the RR as long as it does not depend on any personal or trip characteristics, with the exception on mode and purpose (since the multipliers are determined for each mode purpose combination separately).

9.1 Method for determination of the VTT

9.1.1 General

We use a weighted sample enumeration to calculate the national average VTT for each mode/purpose combination. We use the observed set of respondents with their personal and trip characteristics as the base for this enumeration. This includes respondents recruited both through the internet panel and intercept recruitment. For each respondent, we calculate their VTT using the utility functions described in Chapter 7 and the estimated coefficients discussed in Chapter 8.

Weight factors are applied to match the statistics of our collected sample with national statistics. Separate IPF[18]-procedures for each travel purpose and mode have been performed to calculate these weight factors. Targets for the IPF were obtained from the national travel survey ODiN 2022. For all modes, except air and recreational navigation, optimisation of the weight factors was achieved for the following dimensions (in order of execution):

- Province (12 categories, for business: 4 categories due to smaller data size)
- Time-of-day period (3 categories)
- Gender (2 categories)
- Household size (4 categories)
- Education level (4 categories)
- Age (5 categories)
- Income class (11 categories)
- Trip duration (12 categories)

The minimum trip duration for ODiN-observations was set to 10 minutes, to match the minimum that was used in the survey.

For air respondents travelling via Schiphol, targets were obtained from Schiphol Routes & Profile Monitor 2022 (previously known as the "Continu Onderzoek Schiphol"). Optimization was executed in the following dimensions:

- Age (4 categories)
- Gender (2 categories)
- Destination region (17 categories)

For air respondents travelling via another Dutch airport, weights are based on the total number of Dutch passengers on each of the regional airports (obtained from CBS national statistics), assuming that 80% of the total number of travellers at regional airports are Dutch.

[18] Iterated Proportional Fitting: method to derive the weight factors taking into account that the distribution over certain dimensions must follow some (e.g.) national statistics.

For recreational navigation, no national statistics are available and all respondents got the same weight factor.

Some more relevant details on the precise calculations in the sample enumeration:

- To prevent relative differences between weight factors grow too large, they were only allowed to vary between a factor 0.1 and 10 of the average weight.
- In all Mixed Logit models the VTT was a random variable. This means that the VTT of an individual should be drawn from a lognormal distribution whose parameters were estimated in the model estimation. However, the objective of the sample enumeration is to calculate the national average. To reduce noise in the calculation we assumed that for each respondent in the enumeration, we could take the average of the VTT distribution.
- The intercept interaction coefficient for car that was estimated in the joint SP1A/2A-model was not applied. This means that the VTT obtained from the internet panel forms the base level for the VTT.
- The SP2A interaction coefficient for all relevant modes that was estimated in the joint SP1A/2A models was not applied. This means that the VTT obtained from SP1A data forms the base level for the VTT.
- The SP survey contained two sets of instructions for business respondents: half of them got the first set, the other half got the second set. This was done to allow for at test between two different methods to determine the business VTT (i.e. the HE-method and the WTP-method, see Section 10.3 and Appendix B). For each method, a national average VTT was calculated (i.e. the weights for each half of the data added up to the national total).
- For the sample enumeration of the VTT for airport access and egress separate weight factors have been determined. For the calculation of these weight factors, the target for the distribution over access modes replaced the target for destination region. For this part of the sample enumeration only respondents travelling to/from Schiphol are used. This because only targets for the IPF can be obtained from the Schiphol Routes & Profile Monitor and because it is likely that the distribution over the access modes for travellers using regional airports is very different from that for Schiphol. So, no targets are available for respondents travelling to/from regional airports and these respondents got a weight factor of zero (note that for the sample enumeration for the air in-flight time separate weights were used and respondents using regional airports got non-zero weights for that calculation).

For the calculation of the national average VTT, not only the weights from the IPF are applied (to make the sample representative for the entire travelling population), but the individual VTTs are also weighted by the trip duration (in order to make the final VTT representative for all trip minutes travelled on the Dutch infrastructure).

9.1.2 Number of observations used

Table 9 present the number of observations in our survey that are used for the sample enumeration. Table 25 shows the number of observations taken from ODiN 2022 and the Schiphol Routes & & Profile Monitor 2022 used to determine the targets for the IPF procedure. Table 25 shows that the number business trip observations for train, local public transport and walking is relatively low. These low numbers have negative consequences for the accurate determination of the national average VTT.

Table 25 - Number of observations in ODiN 2022 / Routes & & Profile Monitor 2022

Mode	**Purpose**		
	Commute	Business	Other
Car	12274	5014	45534
Train	1203	294	2151
Local public transport	815	184	2375
Air	-	9240	19875
Cycling	6002	1132	21917
Walking	664	216	23539

9.1.3 Resulting weight factors

The national average VTT will be reported by mode/purpose combination, but also by mode (i.e. combined over all purposes). The combined motorised land modes (i.e. car, train and local public transport) are all reported. To understand how the results by mode/purpose are combined into these higher-level averages, Table 26 presents the distribution of the weight factors by purpose. This table shows that the number of business trips is relatively small compared to the other purposes. For the motorised land modes, only 4.3% of the trips is for this purpose (4.9% of the total number of minutes travelled by these modes).

Table 27 presents the distribution by mode/purpose for all motorised land modes combined. Note that the left side of these tables display the distribution of the weight factors at the level of trips; the right side presents trips at the level of trip-minutes (which is relevant for the calculation of the national average VTT which is also weighted by the trip duration). Table 27 shows that almost 90% of all motorised trips are made by car. When this is calculated by trip minutes, this percentage decreases to 83.5%, which indicates that on average shorter trips are made by car than by train and local public transport.

Table 28 shows the same distribution but for the expansion to the 2010 national travel survey (OViN), which was used for the calculation of the average VTT in the previous study. Commuting by car has decreased from 2010 to 2022, as car commute shares in Table 28 are higher compared to Table 27. Furthermore, the fraction of business trips has increased over the same period of time.

Table 26 - Distribution of weight factors by purpose (for each mode separately)

Purpose / **Mode**	**Distribution of weight factors for trips**				**Distribution of weight factors for trip minutes**			
	Commute	Business	Other	All purposes	Commute	Business	Other	All purposes
Car	21.4%	4.4%	74.2%	100.0%	20.3%	5.0%	74.7%	100.0%
Train	33.5%	4.4%	62.2%	100.0%	29.5%	4.6%	65.8%	100.0%
Local public transport	24.6%	2.9%	72.5%	100.0%	24.1%	2.9%	72.9%	100.0%
Motorised land modes	22.1%	4.3%	73.6%	100.0%	21.5%	4.9%	73.6%	100.0%
Air	-	17.9%	82.1%	100.0%	-	14.1%	85.9%	100.0%
Recr. navigation	-	-	100.0%	100.0%	-	-	100.0%	100.0%
Cycling	22.0%	2.0%	75.9%	100.0%	19.6%	1.8%	78.6%	100.0%
Walking	2.7%	0.5%	96.8%	100.0%	1.6%	0.4%	98.0%	100.0%

Table 27 - Distribution of weight factors by mode/purpose combination (for all motorised land modes together)

Mode \ Purpose	Distribution of weight factors for trips				Distribution of weight factors for trip minutes			
	Commute	Business	Other	All purposes	Commute	Business	Other	All purposes
Car	19.4%	4.0%	67.2%	90.5%	16.9%	4.2%	62.3%	83.5%
Train	1.6%	0.2%	3.0%	4.8%	3.2%	0.5%	7.0%	10.7%
Local public transport	1.2%	0.1%	3.4%	4.7%	1.4%	0.2%	4.3%	5.8%
Motorised land modes	22.1%	4.3%	73.6%	100.0%	21.5%	4.9%	73.6%	100.0%

Table 28 - Distribution of weight factors by mode/purpose combination (for all motorised land modes together) expanded to OViN 2010

Mode \ Purpose	Distribution of weight factors for trips				Distribution of weight factors for trip minutes			
	Commute	Business	Other	All purposes	Commute	Business	Other	All purposes
Car	22.3%	3.0%	64.3%	89.6%	19.5%	3.9%	59.4%	82.9%
Train	2.0%	0.1%	2.6%	4.8%	3.8%	0.4%	6.2%	10.4%
Local public transport	1.8%	0.1%	3.8%	5.7%	2.1%	0.1%	4.6%	6.8%
Motorised land modes	26.1%	3.2%	70.7%	100.0%	25.4%	4.4%	70.3%	100.0%

9.2 Method for determination of the RR

In the estimation of the SP1A/SP2A the same interaction factors apply to the VTT and the VTTR, so the reliability ratio (RR) is identical for all respondents with the same mode and purpose. Consequently, the RR is not affected by the weighting procedure in the sample enumeration and can be taken directly from the SP1A/SP2A estimations. Therefore, it is easier to report the reliability ratio which can be applied directly to the national average VTT if needed. This also prevents the discussion on what to do with the VTT difference that was found between SP1A and SP2A. During the estimations, it was confirmed that the obtained estimates for the RR were stable and consistent between the data from the two- and three-attribute choice questions, and these estimates were also consistent with the findings from our non-parametric analysis. Therefore, we conclude this is a robust method to determine the value of travel time reliability.

9.3 Method for determination of the multipliers

Multipliers for the quality of cycling and walking routes

Cycling/Walking route quality multipliers can be obtained directly from the estimations. Note that no interactions are found with other trip and personal characteristics, so there is no need for a sample enumeration to determine their final values. Note that these multipliers are determined with respect to a reference level which can be arbitrarily chosen. This reference level was set equal to the sample average for the variables in question (in absence of a reported national average). For the calculation of this sample average, the weight factors from the sample enumeration should be applied. The underlying assumption is that the distribution of these variables in the (weighted) sample are also representative for all trips.

Multipliers for the level of crowding

Again, the multipliers for crowding levels do not depend on any trip or personal characteristic, so they can be derived directly from the estimations. There is no need for a sample enumeration. Again, the crowding multipliers are determined with respect to an arbitrary base level which is chosen to be the average level of crowding in the sample.

Multipliers for the components of a public transport trip

These are multipliers for the access/egress part of the trip, for the total waiting and transfer time and for the number of transfers. They are determined with respect to the in-vehicle travel time. In principle, it might have been possible to determine the multipliers with respect to the average total public transport travel time, but that would require that we determine the average fraction that each of these components is of the total travel time. Due to some ambiguities in the data this was not possible, so the final multipliers are with respect to the in-vehicle public transport travel time. These multipliers are directly obtained from the estimations and do not require a sample enumeration procedure.

10. Value of travel time for car, train, local public transport

10.1 Results

To determine the value of travel time for car, train and local public transport, we have taken the models that were discussed in Section 8.1 and applied these in the sample enumeration that was described in Section 9.1. For every respondent in the sample a value of travel time is calculated. Finally, for each mode and purpose combination a weighted average is calculated. The resulting values of time are presented in Table 29. As can be seen from this table, the VTT is generally highest for business trips and lowest for trips for other purposes. For commute the VTT is highest for train and lowest for local public transport. For business and other purposes, the VTT is highest for car.

Table 29 – Value of travel time for (motorised) land modes, in € / hr (price level 2022)

Mode	Purpose			
	Commute	Business	Other	All purposes
Car	10.78	21.20	9.60	10.42
Train	12.05	17.96	8.64	10.08
Local public transport	7.62	14.39	6.66	7.12
All (motorised) land modes	10.76	20.63	9.34	10.19

10.2 Comparison with the results from the 2009/2011 study – non-business

We first compare these results to those from the 2009/2011 study for commute and other purposes. The comparison for business trips will be made in Section 10.3, and the comparison for all purposes combined will be made in Section 10.4.

The results from the 2009/2011 survey are taken from Table 59 in Significance et al. (2013). These were presented at price level 2010. To convert to price level 2022 we have multiplied the values with a factor 1.2953, which both includes a correction for inflation (factor 1.3258) and for 50% of the real income growth (factor 0.9771), as is explained in Appendix D. So, the value for the VTT 2009/2011 at price level 2022 should be interpreted as the expected value for the VTT in 2022 based on the 2009/2011 study. As per Table 30, the VTT found in the 2022 study for individual mode/purpose combinations is between 1% and 24% lower than from the 2009/2011 results and comparable price levels. When compared at the level of all modes together, the difference is -15% for commute and +3% for the other purposes (due to a different weighing of the travel modes).

Table 30 – Comparison VTT for non-business trips between the 2022 and 2009/2011 studies

Mode	Purpose	VTT 2022 Price level 2022	VTT 2009/ 2011 Price level 2010	VTT 2009/ 2011 Price level 2022	Difference
Car	**Commute**	10.78	9.25	11.98	-10%
Car	**Other**	9.60	7.50	9.71	-1%
Train	**Commute**	12.05	11.50	14.90	-19%
Train	**Other**	8.64	7.00	9.07	-5%
Local public transport	**Commute**	7.62	7.75	10.04	-24%
Local public transport	**Other**	6.66	6.00	7.77	-14%
All (motorised) land modes	**Commute**	10.76	9.75	12.63	-15%
All (motorised) land modes	**Other**	9.34	7.00	9.07	+3%

Possible explanations for the decrease of the VTTs in this study with respect to their 2009/2011 study counterparts can be grouped into the following categories:

- explanations intrinsic to the VTT (such as changes in comfort);
- explanations related to the Covid-19 pandemic;
- explanations related to the comparison with the 2009/2011-results;
- explanations related to changes in the research methodology between the 2022 and the 2009/2011 study.

These groups of explanations are discussed in the following subsections.

10.2.1 Explanations intrinsic to the VTT

It is very much possible that the VTT has intrinsically changed in other ways than expected. One of the reasons this study was commenced was that there are several reasons why the VTT can change over time other than inflation and changes in real income growth (which are included in the expected VTT values based on the 2009/2011 results), such as:

- changes in the mix of travellers, or the mix of trips that travellers make;
- changes in the level of observed comfort / convenience that travellers experience;
- changes in the ability of travellers to spend their travel time usefully;
- changes in other comfort / convenience factors and intrinsic preferences from travellers while travelling;
- self-selection effects over time.

These possible reasons will be discussed in more detail below:

Changes in the mix of travellers and trips

As an example: suppose that between 2011 and 2022 there has been a relative shift towards travellers with higher education. It is known from the estimated interaction coefficients (Table 15) that lower educated travellers have lower VTTs (everything else being equal). So, a shift towards higher educated travellers will lead to a higher national average VTT. This is called the composition effect.

To estimate the impact of this composition effect, we have repeated the sample enumeration, but this time with the targets from the OViN 2010 instead of ODiN 2022[19]. In this way, the weighted sample is representative for the travellers and trips in 2010 rather than 2022. Table 31 shows the impact of the composition effect on the VTT. Table 31 shows that the impact of the change in mix of travellers and trips has likely resulted a VTT increase of about 3%. In other words, this change in the mix has dampened the VTT decrease slightly and cannot explain the decrease itself.

Table 31 – Comparison VTT for non-business trips when expanded to ODiN 2022 or OViN 2010

Mode	Purpose	VTT 2022 Price level 2022 Expanded to ODiN 2022	VTT 2022 Price level 2022 Expanded to OViN 2010	Difference
Car	Commute	10.78	10.47	+3%
Car	Other	9.60	9.27	+4%
Train	Commute	12.05	12.23	-1%
Train	Other	8.64	8.22	+5%
Local public transport	Commute	7.62	7.46	+2%
Local public transport	Other	6.66	6.24	+7%
All (motorised) land modes	Commute	10.76	10.49	+3%
All (motorised) land modes	Other	9.34	8.98	+4%

Changes in the levels of observed comfort and convenience

To illustrate, suppose that the level of comfort of a trip has improved between 2011 and 2022. Subsequently, travelling has become less of a nuisance for the traveller over time and this will result in a lower VTT, which can be interpreted as the disutility of travel time (in units of the disutility of spending money).

Observed comfort and convenience includes all attributes that relate to comfort and convenience that in principle can be included in the models. The most relevant ones are:

- the amount of congestion for car drivers
- the level of crowding for public transport users
- the number of transfers that a public transport user has to make during his trip

Note that these factors have not been explicitly modelled in our utility functions (though the latter two are part of the SP3A and SP4A experiments), but in principle they could have been taken into account.

We have not asked about the amount of congestion in either the 2009/2011 survey or the 2022 survey, but we can use information from the Rapportage Rijkswegennet which is regularly published by Rijkswaterstaat. Over 2011[20] they reported 13.9 million kilometre-minutes of congestion (i.e. the congestion length multiplied by its duration) and a total of 64.7 billion kilometres travelled on the "Rijkswegennet" (i.e. the main road infrastructure in the Netherlands). This amounts to an average congestion level of 0.162 kilometre-minutes for every 1000 km travelled. In 2022 14.4 million kilometre-minutes of congestion and a total of 67.4 billion kilometres travelled were reported, translating to an average congestion level of 0.214 kilometre minutes for every 1000 km travelled. In other words, the relative amount of congestion has increased between 2011 and 2022, which is likely to

[19] OViN ("Onderzoek Verplaatsingen in Nederland") is the national travel survey that was conducted yearly between 2010 and 2017. From 2018 onwards, some changes in the methodology were implemented and this survey was called ODiN ("Onderweg in Nederland"). OViN 2010 was used in the 2009/2011 study as the targets for the sample enumeration.

[20] The national average VTT in the 2009/2011 study was determined based on the 2011 respondents only. Data from the 2009 respondents was only used to enhance the determination of all interaction factors. Therefore, in this comparison the congestion level in 2011 is relevant.

be more of a nuisance for car drivers, possibly leading to a higher VTT. It is therefore not conceivable that this can explain why the VTT has decreased.

Although we have asked about the level of crowding for public transport users in the 2022 survey, we have not asked the same question in the 2009/2011 survey. The NS yearly reports the probability of finding a seat in the train during the peak hours, however this has only been reported from 2016 onwards. So, it is not possible to estimate the size of the possible impact of this factor. However, between 2016 and 2022 the reported probability of finding a seat during peak hours has reduced from 98.7% to 96.6%. Due to the growth of train passenger numbers (also relative to the number of available trains), it is unlikely that this probability in 2011 was lower than in 2022. So, it is plausible that crowding has deteriorated since the last VTT study, which is likely to have caused on increase in the VTT. Again, it cannot explain the observed decrease of the VTT.

For public transport trips, we have asked about the number of transfers in both surveys. The results are shown in Table 32. As can be seen from this table, the average number of transfers during a (standardised) train trip has remained constant between 2011 and 2022. That being said, for local public transport the number of transfers has reduced by 0.3 transfers per (standardized) trip. This might have made these trips more comfortable, and hence contributed to a reduction of the VTT. If we use the transfer penalty for local public transport that is derived from SP3A (i.e. 12.24 minutes, see Section 14.1), we can estimate that the impact of this improved convenience on the VTT is about 6%.

Table 32 – Average number of transfers per public transport trip in 2022 and 2011

	2022			2011			2022 – 2011
	Average number of transfers per trip	Average duration per trip	Average number of transfers per 60 min. duration	Average number of transfers per trip	Average duration per trip	Average number of transfers per 60 min. duration	Difference in average number of transfers per 60 min. duration
Train	0.529	112.3	0.283	0.431	91.7	0.282	+0.001
Local public transport	0.278	76.9	0.217	0.455	52.6	0.519	-0.302

Changes in the ability of travellers to spend their travel time usefully

General improvements in the access to technology have been the main arguments in several VTT studies to explain a reduction in the VTT. In the past, the introduction of mobile phones have been used to explain a decrease of VTT. Since 2010 smartphones have become widely available. In addition, internet services (3G/4G networks and public transport Wi-Fi networks) have significantly improved since 2011. Entertainment service content such as music, video, books and television are more accessible than ever. Increased storage size in mobile devices allows us to enjoy these services even when internet is unavailable. Car travellers enjoy more radio stations and car entertainment systems allow to have your own content available at any moment. Additionally, phone conversation quality has gone up as well.

Kouwenhoven and de Jong (2018) have tried to find a relationship between the VTT and the availability of technology, but they were unsuccessful. This was probably caused by self-selection and other effects: only people with higher incomes and with busier schedules have certain devices available during their trip. These devices may lower their VTT, but these travellers may still have higher VTTs than average. Furthermore, respondents who do not benefit from having such a device available, usually do not bring such a device. This implies that respondents who have or do not have such a device available belong to different population segments, which makes it difficult to determine the impact of having such a device with everything else being equal.

However, Kouwenhoven and de Jong (2018) were successful in finding a relation between the VTT and the (self-reported) ability of a respondent to use his travel time in a useful way. Travellers in a train or by local public transport who can spend their travel time usefully have about a 20% lower VTT. Suppose that in 2022 more respondents can spend their travel time in a useful way than in 2011, this may have contributed to the observed decrease in the VTT. Indeed, Table 33 shows that all travellers, except car-commute and train-commute, have increasingly been able to use their travel time usefully. We estimate that this has contributed to a decrease in the VTT of about 1-2% (while it may have increased the VTT for train-commute by 1%). Note that in this estimate we have assumed that the VTT difference of 20% between those who could and could not use their travel time usefully, remained unchanged. Note that no relation between this percentage and the VTT was found for car, so for that mode the table does not show any impact on the VTT.

Table 33 – Percentage respondents that were able to use their travel time usefully in 2022 and 2011

Mode	Purpose	Percentage respondents that were able to spend their travel time usefully		Difference	Estimated impact on VTT 2022
		2022	2011	2022-2011	
Car	**Commute**	37.6%	38.7%	-1.1%	
Car	**Other**	54.6%	39.8%	14.8%	
Train	**Commute**	71.0%	74.3%	-3.3%	+1%
Train	**Other**	73.7%	67.9%	5.8%	-1%
Local public transport	**Commute**	62.0%	54.6%	7.4%	-2%
Local public transport	**Other**	60.1%	50.7%	9.4%	-2%

Changes in other comfort / convenience factors and intrinsic preferences from travellers while travelling

Other less tangible factors might also have affected the VTT. This includes the physical comfort of sitting in cars, trains and busses – which has generally increased in the last 10 years – and other comfort and convenience factors. They might also have had an impact on the VTT.

Furthermore, intrinsic preferences might also have changed. Travellers may have gotten used to travelling more or may have accepted all nuisances that are attached to travelling more and do not mind it as much as they may have done in the past (e.g. a Dutch study on congestion (KiM 2019) revealed that travellers considered congestion in 2019 less of a problem than they did in 2010) This may be one of the most important explanations in the decrease of the VTT, though it is very difficult to find hard evidence for this.

Self-selection effects over time

Over time, travellers may not stay with the same mode. It is likely that especially travellers with relatively high VTTs switch to another (faster) mode, leaving the travellers with relatively lower VTTs with their original mode. This will lower the average VTT for that mode over time. For instance, it might be that travellers with a relatively high VTT that used to take public transport have switched to an electric bike which might be quicker for them to reach their destination. This will result in a lower VTT for public transport.

10.2.2 Explanations related to Covid-19

It is also possible that the VTT has temporarily changed due to the effects of the Covid-19 pandemic. The main fieldwork period was executed in June and September 2022. In those periods, no lock-down was in place, no faces masks were required to be worn when travelling and vaccination levels were high. These periods also coincided with periods with relatively low numbers of Covid-19 contaminations and Covid-19-related deaths (Figure 17). So, it is fair to say that life was more or less back to normal when the fieldwork was executed. However, not everything was yet normal: people were still working at home more than (the new) normal; road congestion and public transport ridership was not yet back to their pre-Covid-19 levels. In addition, the pandemic was still something "recent" and may have affected how people perceive their travel time.

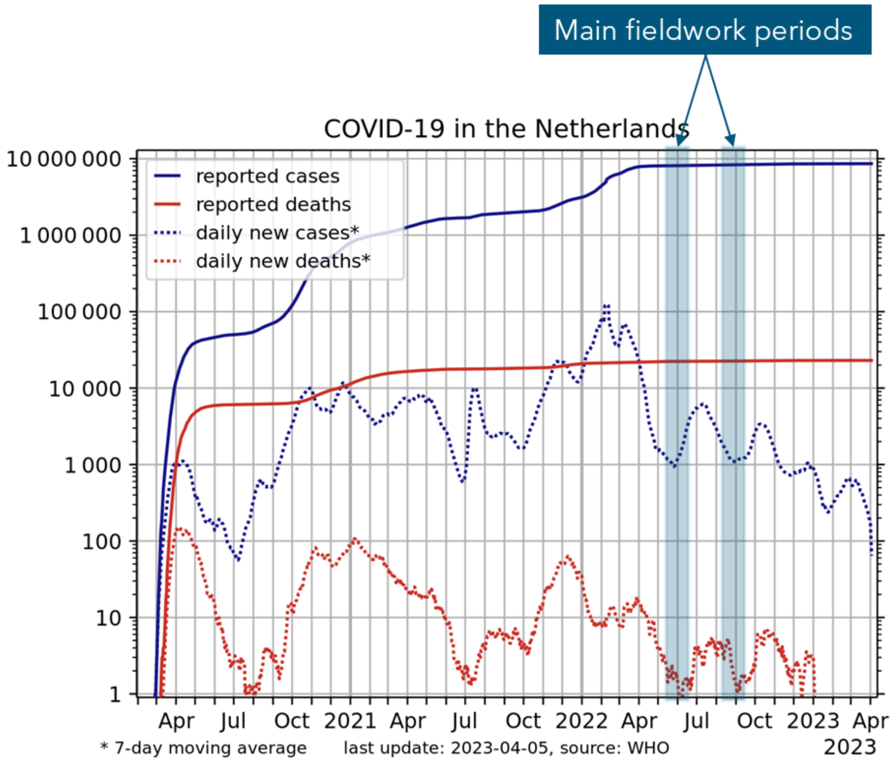


Figure 17 – Number of daily Covid-19 cases and deaths in the Netherlands. Source: Wikipedia: By Hbf878 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=88396858

The possible effects of Covid-19 on the travel behaviour can be grouped as follows:

1. **Frequency effect (1)**: Fewer people travel.
2. **Frequency effect (2)**: Specific groups of people travel less, or do not travel at all for certain purposes (e.g. white collar employees work more from home).
3. Effect on **mode choice**: people travel by different modes (e.g. former train travellers currently travel by car because of the greater perceived risk of contamination (distance to other travellers), or because of reduced road congestion.
4. Effect on **destination choice**: people travel to different locations.
5. Effect on **time-of-day choice**: people travel at different times (e.g. because of congestion has reduced during the peak hours since fewer people travel (= effect 1 and 2)).
6. Effect on **congestion**: the amount of road congestion may be lower since fewer people travel. This affects the travel times and the fraction of the trip duration that is spent in congestion. Since travelling in congested conditions is valued differently from free-flow conditions, this will affect the average VTT and possibly the VTTR of road modes.
7. Effect on **crowding**: the level of crowding may be lower and also the fraction of the trip duration that is spent in highly crowded conditions. Since travelling in highly crowded conditions is valued differently from low-crowding conditions, this will affect the average VTT in public transport.
8. Effect on **how the travel time is experienced**: people may experience a minute of travel under the same conditions as before still differently from pre-Covid-19 times (e.g. because of the risk of getting infected, but also because they are enjoying a once-in-a-while trip to their office more than the every-day trip they used to make before the Covid-19 outbreak).

To investigate whether the first five effects are still important effects captured in our 2022 data, we have repeated the sample enumeration but this time with the targets from the ODiN 2019 instead of ODiN 2022. In this way, the weighted sample is representative for the travellers and trips in 2019 rather than

2022. Note that this analysis is like the one described in Section 10.2.1, where an expansion was made to OviN 2010. Any change that is found between 2019 in 2022 in the current analysis, will also be included in the comparison between 2010 and 2022. In other words: any difference found in this analysis will inform which part of the previously found changes may be due to Covid-19 and hence may be temporary.[21]

Table 34 shows the impact of the VTT as a result of this change in the mix of travellers and trips between 2019 and 2011. The values in Table 34 demonstrate that the impact of the change in mix of travellers and trips for these mode-purpose combinations has been very limited. The maximum effect is +/-1%. The table also shows the result from Table 31. The effects found between 2019 and 2022 are generally in line with those found over the longer period between 2010 and 2022, with the possible exception for local public transport trips made for other purposes. So, generally we do not think the first five effects played any role in our analysis for the non-business trips (with the aforementioned exception).

Table 34 – Comparison VTT when expanded to ODiN 2022 or OViN 2010

Mode	Purpose	**VTT 2022** Price level 2022 Expanded to ODiN 2022	**VTT 2022** Price level 2022 Expanded to ODiN 2019	**Difference 2022 - 2019**	**Difference 2022 - 2010** (from previous table)
Car	**Commute**	10.78	10.90	+1%	+3%
Car	**Other**	9.60	9.69	+1%	+4%
Train	**Commute**	12.05	12.07	+0%	-1%
Train	**Other**	8.64	8.70	+1%	+5%
Local public transport	**Commute**	7.62	7.65	+0%	+2%
Local public transport	**Other**	6.66	6.58	-1%	+7%
All (motorised) land modes	**Commute**	10.76	10.87	+1%	+3%
All (motorised) land modes	**Other**	9.34	9.38	+0%	+4%

To investigate if the sixth effect (reduced congestion) was still important, we checked the Rapportage Rijkswegennet again. Over 2019, Rijkswaterstaat reported 13.3 million kilometre-minutes of congestion (i.e. the congestion length multiplied by its duration) and a total of 72.9 billion kilometres travelled on the “Rijkswegennet” (i.e. the main road infrastructure in the Netherlands). This is amounts to an average congestion level of 0.182 kilometre minutes for every 1000 km travelled. In 2022, we had an average congestion level of 0.214 kilometre minutes for every 1000 km travelled, which is much higher than the congestion level of 0.162 that was found for 2011. So, the congestion level in 2022 was not yet at the level it reached in 2019. From this, it can be expected that the VTT for car drivers will increase slightly if congestion is back at its pre-Covid-19 level, although it is difficult to believe that this will have a strong impact. The congestion level in 2022 is still worse than it was in 2011 and the VTT has clearly decreased nevertheless, so we do not expect a strong dependency between the VTT and congestion.

To investigate whether the seventh effect (reduced crowding) was still relevant, we checked the Annual Report of NS again. Over 2022, NS reported a probability of finding a seat during the peak hours of 96.6%, while this was 94.9% in 2019. Similar to the previous finding on congestion, also the nuisance of travelling by train (i.e. crowding) was not yet the 2019 level in 2022. Again, it can be expected that the VTT for train users will increase slightly if probability of finding a seat during peak hours has returned to its pre-Covid-19 level, and again it is difficult to believe that this will have a strong impact. The probability of finding a seat in 2022 is still worse than it was in 2011; so a likewise logic as in the previous paragraph is valid here as well. We do not expect a strong dependency between seat probability and the VTT.

The existence of the eight and last effect (i.e. change in how travel time is experienced) has proven to be challenging to research. It is conceivable that travellers were still anxious to travel in the close proximity

[21] With the exception for any structural increase in the level of working from home.

of others since they learned about the contamination risks during the pandemic. However, if this would have had a large impact on the VTT, a clear VTT increase should have been visible. Instead a decrease was observed. Furthermore, this effect would have likely impacted the crowding multipliers. But, as will be shown in Section 14.3, there is no indication that the multipliers in this study are higher than might be expected.

From the discussion above, we conclude that the Covid-19 pandemic might have led to a slight increase in the VTT, and that this cannot contribute to the explanation of the observed VTT decrease.

10.2.3 Explanations related to the comparison with the 2009/2011-results

We started this discussion with a comparison between the 2022-results and the expected VTT based on the 2009/2011-results, corrected for inflation and (half of the) real income growth. The discussion in the previous two sections regarded the 2022-results and how this may have been affected by all kinds of factors. However, it is also possible that there are biases and uncertainties in the calculation of the expected VTT based on the 2009/2011-results. To discuss those we look at the following factors:

- the correction for inflation
- the correction for real income growth
- the uncertainty in the 2009/2011-results
- possible biases in the 2009/2011-results

These will be discussed in the following paragraphs.

Correction for inflation

Typically, inflation is approximately 1-3% per year and correcting for it in the VTT calculation is a straightforward exercise. In contrast, 2022 showed a highly irregular inflation pattern. In 2022 the CPI increased sharply during the summer months due to the increase in gas prices. However, not every consumer might have felt these effects directly; especially households with long term energy contracts and subsequent stable energy bills. So, while the inflation increase is formally correctly calculated (10% growth with respect to 2021), it may not have been substantialised into the time and cost preferences of travellers. The inflation that travellers actually perceived when completing the SP experiments might have been (much) lower. This could favour the argument that we should not have used the 2022 CPI, but rather a 2021 CPI with a more typical inflation increase. This would lower the VTT 2009/ 2011 at price level 2022 in Table 30 by about 8%, and also the difference between the 2022 VTT and the expected VTT based on the 2009/2011 result by about 8 percentage points.

Correction for real income growth

It is common practice in the Netherlands to correct the VTT yearly by inflation and by half of the real income growth. This factor 0.5 is based on (amongst others) the comparison between results from the 1988 and the 1997 surveys (Gunn 2001), but in the international literature all kind of factors between 0 and 1 have been found (Börjesson et al. 2023), so the factor of 50% as found by Gunn should be considered as uncertain.

To illustrate the possible impact of this: suppose that the expected VTT is corrected for 100% of the real income growth, the difference between the 2022-result and the 2009/2011 results becomes 2 %-points smaller than reported in Table 30. Suppose that the expected VTT is corrected for 0% of the real income growth, the difference between the results becomes 2 %-points larger.

Uncertainty in the 2009/2011 results

In Section 12.1 we will discuss the size of the uncertainty in the 2022-results and we will show that it is typically 3-5%. This uncertainty scales with the square root of the number of respondents. Since the number of respondents in the 2011 survey (which is used as the main source for the determination of the VTT in the 2009/2011 study) is about a factor of 3 smaller than in the 2022 survey, a simple estimate for the uncertainty in the 2009/2011 results is typically 5-9%. This is substantial compared to the difference that is found between the results of both studies, and it could explain a (substantial) part of it.

Possible biases in the 2009/2011-results

In Section 8.1.2, we have discussed that in our final models the VTT for car drivers was 16% higher for respondents recruited at intercept locations compared to respondents recruited via an internet panel.

However, for the calculation of the national average we did not apply this factor. In other words, we believe that the car respondents recruited at intercept locations were biased as a result of a self-selection effect. Note that the VTT for car from the 2009/2011 study was based entirely on respondents recruited at these (or very similar) locations. It is therefore likely that the 2009/2011 result has suffered from the same self-selection effect, and hence is over-estimated by about 16%.

10.2.4 Explanations related to the methodology

As explained before, we have tried in this study to use as much as possible the same methodology as was used in the 2009/2011 study. However, at some points we have chosen to make adaptations. These might also have impacted the results.

Some of these changes have already been discussed (e.g. the use of intercept or internet panel respondents). Three other important changes are:

- changes in the SP design
- changes in the utility formulation
- changes in the rewards given for participation

Impact of changes in the SP design

In the 2009/2011 and the 2022-surveys different experimental designs for the SP experiments were adopted. The 2022-design covered a much larger part of the tail of the VTT distribution which allowed for a much better determination of the VTT distribution (see Appendix A).

To investigate the effect of the new design, we have offered approximately 5% of the respondents in the 2022-survey a set of choice tasks based on the old design from the 2009/2011 study. In the analysis, a VTT interaction coefficient was tried to be estimated for having the old design. However, this interaction coefficient was never significant, which confirms that the new design should (in principle) not have had any impact on the VTT.

Impact of changes in the utility formulation

The test described above showed that no significant difference was found between the old and new design, given that we use the 2022-formulation of the utility. This utility formulation was based on the same RU-LIN approach as was used in the 2009/2011 study, but both formulations also had their differences: the set of interaction factors, how these interacted with time and cost and in what way the unobserved heterogeneity was included in the model (Latent Class in 2009/2011 and Mixed Logit in 2022).

A test with an estimation of the 2009/2011 data using the 2022 utility formulation was not successful. It seems that the 2009/2011 design may not for all modes have covered the tail of the VTT distribution sufficiently, or that the 2009/2011 data set may not have been large enough to estimate plausible Mixed Logit models. Future research could try to estimate a model on the 2022 data using the 2009/2011 utility formulation (including Latent Class), since this has not been tried within this study.

Impact of the changes in the rewards given for participation

The reward given to respondents for finalising the survey was different for the 2009/2011 and 2022 study. In 2009, panel respondents were compensated with a relatively low reward of the equivalent of €1.50. In 2011 intercept respondents could participate in a price draw. In 2022 panel respondents got a compensation of € 3 for their participation and intercept respondent even got € 10 to stimulate response rates. These increased rewards have clearly led to improved response rates (as discussed before), but it is unclear and impossible to determine whether this might also have had an impact on the VTT.

10.2.5 Summary of possible explanations

In the previous sections, several possible explanations have been provided on why the VTT from this study differs from the expected VTT based on the 2009/2011 study. The size of some of these explanations have been estimated. Table 35 shows an overview of these explanations. Based on the contents of this table, it can be concluded that the biggest contribution to the observed difference are likely to be given by (in order of the discussion):

- Reduction in the number of transfers for local public transport users

- Change in general comfort levels and preferences
- Self-selection effects in which travellers with relatively high VTTs switch to faster modes over time
- Uncertainty on how inflation should be included in this comparison
- Uncertainty margins in the results
- Use of respondents recruited at intercept locations for the car VTT in the 2011-study

Table 35 – Overview of possible explanations for the difference between the 2022 and 2009/2011-studies

Mode	Purpose	Difference 2022 - 2009/2011	Effect different mix	Effect increased congestion / crowding + reduced numb. transfers	Effect change in use of travel time	Effect change general comfort / preferences	Self-selection effects over time	Using inflation correction until 2021 i.s.o. 2022	Effect of real income growth	Uncertainty	Intercept
Car	**Commute**	-10%	+3%	+ ??	0%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	-16%
Car	**Other**	-1%	+4%	+ ??	0%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	-16%
Train	**Commute**	-19%	-1%	0%	1%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	
Train	**Other**	-5%	+5%	0%	-1%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	
Local PT	**Commute**	-24%	+2%	-6%	-2%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	
Local PT	**Other**	-14%	+7%	-6%	-2%	– ??	– ??	-8%	+/- 2%	+/- 5-9%	

It is advised to use the values obtained from the new 2022-study, as these are based on newer data, includes the latest preferences from travellers, has been derived on more data and has been based on a state-of-the-art methodology.

10.3 Comparison with the results from the 2009/2011 study – business

We now compare the results from the 2022 study with those from the 2009/2011 study for business purposes. The results from the 2009/2011 survey are corrected for inflation and for 50% of the real income growth. The resulting expected value for the VTT based on the 2009/2011 survey is shown in Table 36.

Table 36 – Comparison VTT for business trips between the 2022 and 2009/2011 studies

Mode	Purpose	VTT 2022 Price level 2022	VTT 2009/ 2011 Price level 2010	VTT 2009/ 2011 Price level 2022	Difference
Car	**Business**	21.20	26.25	34	-38%
Train	**Business**	17.96	19.75	25.58	-30%
Local public transport	**Business**	14.39	19.00	24.61	-42%
All (motorised) land modes	**Business**	20.63	24.00	31.09	-34%

From Table 36, the VTT found in the 2022 study is 30-42% lower than expected from the 2009/2011 results. This is much stronger decrease than the 5- 24% that was found for non-business modes. Many of the explanations for the VTT difference for non-business that were discussed in the previous section, also apply to business travellers. However, the explanation regarding "Changes in the mix of travellers and trips" has a different impact on business trips compared to non-business trips. Secondly, there has been a substantial methodological change.

Changes in the mix of travellers and trips

In Section 10.2.1 it was shown that the mix of travellers and trips changed slightly for non-business trips between 2010 and 2022, and that this will have resulted in an increase of the VTT of about 3-4% on average. However, for business trips this is different. Table 37 shows that the change in the mix of travellers and trips that they make is likely to have reduced the VTT between 2022 and 2010 by 15-26%. So, business trips in 2010 are clearly different from business trips in 2022. A likely explanation are the increased possibilities for remote work and online meetings. Especially highly educated, high income business travellers are likely to substitute in-person meetings for remote work alternatives, which will reduce the average VTT for business. Another explanation might be that business trips in 2022 are on average shorter than in 2010.

Both effects are partly related to the Covid-19 pandemic. Table 37 also shows the impact of composition effect since 2019. This impact is about half of the total impact over the period 2010-2022. So, the ongoing trend between 2010 and 2019[22] has been accelerated since then.

Table 37 – Comparison VTT for business trips when expanded to ODiN 2022, OViN 2010 or ODiN 2019

Mode	Purpose	VTT 2022 Price level 2022 Expanded to ODiN 2022	VTT 2022 Price level 2022 Expanded to OViN 2010	Difference 2022-2010	VTT 2022 Price level 2022 Expanded to ODiN 2019	Difference 2022-2019
Car	**Business**	21.20	25.06	-15%	22.59	-6%
Train	**Business**	17.96	24.32	-26%	20.30	-12%
Local public transport	**Business**	14.39	17.26	-17%	15.62	-8%
All (motorised) land modes	**Business**	20.63	24.85	-17%	22.18	-7%

Methodological change: WTP-method compared to the Hensher-method

Business trips are different from non-business trips. After all, trips for commute and other purposes normally take place in the travellers' own time and are paid for by the travellers themselves (though some compensation for commuting costs may be in place). Business trips on the other hand, usually take place during work hours (i.e. the employers' time) and are fully paid by the employers. Therefore, the business VTT consists of two components: the VTT of the employee (i.e. the traveller) and of the employer.

In the 2009/2011 survey, the employee component of the VTT was determined using a standard SP experiments where the travellers had to assume that they were travelling in their own time / at their own cost (similar to the method for all other purposes). The employer component was determined using the Hensher equation (HE). This equation assumes that the employer component depends on the marginal productivity of work time, but some share of this travel time is spent working, although the productivity of this time is not quite as high as that of working at the workplace. When travel time is spent working, this reduces the employer component. A full description of this method can be found in Appendix B.

In other international studies a different method is used, where the travellers are asked during the SP to also include the interests of their employers. They are no longer instructed to assume that they are travelling in their own time and at their own cost. This is called the Willingness-to-Pay (WTP) method. It has been argued that this is to be preferred, since not all business trips occur entirely during work hours. Some trips transpire outside work time, but if travel time is saved for such a trip, that time results in more private time for the traveller rather than more work time for the employer.

The recent international literature shows a slight preference for a direct WTP approach. But the argument of consistency with previous Dutch studies favoured the HE method. It was decided at the

[22] Part of this observed trend may be due to differences between the OViN and ODiN methodology for conducting the national travel survey.

beginning of this study that 50% of the business travellers would be used to determine the VTT using the HE-approach, and for the other 50% the WTP approach would be used. The difference between these two groups of respondents is in the instructions they receive when doing the SP experiments. This would allow us to determine the difference between both approaches. Also prior to the study, it was decided that if both methods would lead to plausible results, it would be recommended to use the results from the WTP method, given the slight preference for this method based in the international literature.

A full description of this combined method used for business travel is provided in Appendix B. The main results of the analysis are shown below. Table 38 shows the resulting VTT based on the HE approach and the WTP approach. The VTTs based on the WTP method are between 22% and 32% lower than the VTTs based on the HE method. Since both values are plausible, the VTTs from the WTP method will be used as output from this study. Consequently, these WTP values were already mentioned in the earlier tables with the overview of the VTTs from this study (see Table 29 and Table 36).

This also implies that a large part of the observed difference between the VTT from this study versus the 2009/2011 study is due to this methodological change. Indeed, if the VTTs based on the HE approach are compared to the VTTs from the previous study, the difference is much smaller: 7-21% lower (Table 39), rather than 30-42% lower based on the WTP approach.

Table 38 – Comparison VTT for business travel using the HE and WTP approach

Mode	**Purpose**	**HE approach**			**WTP approach**	**Difference**
		Employee component	Employer component	Total VTT	VTT	Rel. diff. WTP vs. HE
Car	**Business**	16.56	15.07	31.63	21.20	*-32%*
Train	**Business**	16.07	6.99	23.06	17.96	*-22%*
BTM	**Business**	10.29	9.98	20.27	14.39	*-29%*

Table 39 – Comparison VTT between 2022 and 2010 surveys, both based on the HE approach

Mode	**Purpose**	**VTT 2022** HE approach Price level 2022	**VTT 2009/ 2011** Price level 2022	**Difference**
Car	**Business**	31.63	34.00	*-7%*
Train	**Business**	23.06	25.58	*-11%*
BTM	**Business**	20.27	24.61	*-21%*

10.4 Comparison with the results from the 2009/2011 study – all purposes combined

Finally, we compare the results from the 2022 study with those from the 2009/2011 study for all purposes combined. This means that we use the sample enumeration to calculate the VTT per mode, irrespective of the trip purpose. The results from the 2009/2011 survey are corrected for inflation and for 50% of the real income growth. The resulting expected value for the VTT based on the 2009/2011 survey is shown in Table 40.

Table 40 – Comparison VTT for all purpose trips between the 2022 and 2009/2011 studies

Mode	Purpose	VTT 2022 Price level 2022	VTT 2009/ 2011 Price level 2010	VTT 2009/ 2011 Price level 2022	Difference
Car	**All**	10.42	9.00	11.66	-11%
Train	**All**	10.08	9.25	11.98	-16%
Local public transport	**All**	7.12	6.75	8.74	-19%
All (motorised) land modes	**All**	10.19	8.75	11.33	-10%

From Table 40 the VTT as found in the 2022 study is 10-19% lower than expected from the 2009/2011 results. This is consistent with what was found for non-business trips and is less than what was found for business trips. This is comprehensible, since business trips only form about 4% of the total number of motorised trips.

11. Value of travel time for other modes

11.1 Air (flight and access/egress to/from airport)

11.1.1 Results

To determine the value of travel time for the flight component, access component and egress components of an air trip, we have taken the models that were discussed in Section 8.2 and applied these in the sample enumeration that was described in Section 9.1. Note that the flight component is defined as the part of trip between the departure at the first airport until the arrival at the last airport of the journey, so it includes any possible transfer.

For every respondent in the sample a value of travel time is calculated. Finally, for each mode and purpose combination a weighted average is calculated, except for commute for which purpose not enough observations were available to estimate a VTT. The resulting values of time are presented in Table 41.

Table 41 – Value of travel time for air (in-flight, access to airport, egress from airport, average over access and egress, in € / hr (price level 2022)

Component	Mode	Purpose		
		Business	Other	All purposes
Flight	Air	110.22	53.80	61.79
Access	Kiss & fly	26.96	12.19	14.72
	Park & fly	20.78	9.32	10.21
	Taxi	17.34	8.53	10.97
	Train or train+bus	8.62	5.04	5.83
	All modes	15.48	8.28	9.58
Egress	Kiss & fly	36.01	15.60	16.42
	Park & fly	16.40	12.91	13.51
	Taxi	53.89	18.91	32.05
	Train or train+bus	21.41	11.48	12.39
	All modes	27.97	13.25	15.33
Average access / egress	Kiss & fly	31.49	13.90	15.57
	Park & fly	18.59	11.12	11.86
	Taxi	35.62	13.72	21.51
	Train or train+bus	15.02	8.26	9.11
	All modes	21.73	10.77	12.46

11.1.2 Discussion

From Table 41 it follows that the VTT for access and egress is much lower than for the flight component. Also note that the VTT for egressing from the airport is generally larger than the VTT for accessing to the airport. The access VTT applies to persons living in the Netherlands that are travelling to Schiphol or another Dutch airport for a flight to a foreign destination. This may be the start of a holiday or a business tour. People may be anxious that they might be late and miss their flight. However, due to the set-up of the SP experiment the influence of this probability is separated from the determination of the value of the access travel time. The egress VTT applies to persons living in the Netherlands that just had their return flight back home and are at the last stage of their tour. In most cases, they are travelling back home. They may be tired of a long trip and may be eager to get home. This might explain why their VTT is higher when egressing from the airport than when accessing to the airport.

Note that the VTTs for access and egress are generally higher than the "normal" values of travel time by the same mode. This can be partly explained by socioeconomic and trip characteristics (people travelling by air might have generally a higher income than the average traveller by the same (access/egress) mode, and they might make longer trips to travel to the airport than an average traveller is making). But it might also be explained by an intrinsic difference: people are eager to travel to or from the airport and are willing to pay a larger amount for a shorter trip. At the same time, it was not expected *a priori* that the VTT for this type of travel would differ by a large amount from the VTT for normal travel given that the additional anxiety of missing a flight has been properly separated from the pure valuation of the travel time. The results are indeed consistent with this *a priori* expectation.

Comparison of the VTT for the flight component with 2009/2011 study

In the 2009/2011 study a VTT for "air" was determined also. Similarly, that VTT referred to the flight component of an air trip, so they can be compared directly after correcting for inflation and for 50% of the real income growth. The 2022-VTT for business trips turns out to be 1% lower than expected based on the 2009/2011 results; for other trips the 2022-VTT is 12% lower (Table 42). This last difference is in line with the differences found for car, train and local public transport. The difference for business trips might seem low, since that also includes the effect of the methodological change. However, the 2009/2011 study showed that for air trips the employer component (as determined with the Hensher equation) was small. Table 82 in Appendix B shows that also in this study the employer component is relatively small compared to the employee component. For this reason, we do not expect a large methodological effect between the HE-method and the WTP-method. On the other hand, the same table shows a large difference between the two methods, with the VTT based on the HE-method 30% lower than the WTP-method (note that this is opposite compared to the other modes). This is remarkable. The number of respondents (i.e. 340 of which about half got the HE-instructions and half the WTP-instructions) seem sufficient to get accurate VTT estimates. It is unclear what else might have caused this difference.

Table 42 – Comparison VTT for the flight component of an air trip between the 2022 and 2009/2011 studies

Mode	Purpose	VTT 2022 Price level 2022	VTT 2009/2011 Price level 2010	VTT 2009/2011 Price level 2022	Difference
Air	Business	110.22	85.75	111.08	-1%
Air	Other	53.80	47.00	60.88	-12%

Comparison of the VTT access / egress with literature

In the Netherlands only one earlier study has investigated the value for travel time to and from the airport. For his PhD thesis Paul Koster (2012, also published in Koster et al. 2011) collected data from 971 Dutch air travellers (345 business traveller and 626 non-business travellers). His internet survey focussed on the respondent's trip to the airport and included estimation results for an SP experiment on this trip for 883 respondents. The set-up of the SP5A experiment in our study was based on the Koster-experiment, with similar attributes and attribute ranges. Koster estimated a Mixed Logit linear RU-model in willingness to pay space with expected scheduling terms, i.e. the amount of time that the traveller is expected to arrive early or late compared to the preferred arrival time. He found an access VTT for business of €42.87 and for non-business of € 31.23 (price level 2009, Koster et al. 2011, Table 5). Even before correcting for inflation, this is much higher than found in our VTT study.

Of course, it is possible that the VTT for access has diminished since 2010 for similar reasons as discussed in Section 10.2.1, but the difference between the results of the two studies seem too large for this to be the only explanation. Other possible explanations are:

- Differences in the presentation of the SP attributes
  - In the SP5A experiment, six attributes are presented including the additional time at the airport. This attribute is not explicitly presented by Koster et al. (2011), though it can be calculated by the respondents from the values of the other attributes.
  - The probability of missing a flight is presented in the SP5A flight as “1 out of ... times”, whereas Koster et al. have presented it as a percentage (see Table 4 of their paper). It is possible that not all respondents in the Koster-study have understood this correctly, which might have resulted in a contamination of the VTT with the value of missing a flight.
- Differences in the design of the SP
  - In SP5A slightly different ranges for the attributes have been used compared to Koster et al. (see Table 4 of their paper)
    - In our SP experiment, the travel time ranged from -30% to +50% of the current travel time (comparable to the range in SP1A), whereas in Koster et al. it ranged from -15% to +20%
    - Both the attributes on the additional time at the airport and the probability of missing a flight had comparable ranges in both studies, although Koster et al. used a level of 0% probability of missing a flight, which was not used in SP5A.
    - The range of the cost attribute was determined in a very different way in both studies. Koster et al. used cost per minute levels that depended on the current duration of the trip, whereas in SP5A they were related to the current cost level. In many cases, this led effectively to similar ranges for the cost, but for respondents with relatively high current costs this led to non-overlapping cost levels
    - The underlying design was different. In their paper, Koster et al. (2011) wrote “... there is a possibility that the design was not able to produce reasonable trade-offs for schedule delay late and the probability to miss a flight for some of the respondents”.

      It might be their use of a lognormal distribution was not optimal. Indeed, a re-analysis of the Koster-data using a comparable panel Latent Class model with 5 classes showed a negative skewness for the access VTT distribution (skewness=-0.49, unlike a lognormal distribution which has a positive skewness), but not for the other attributes. The estimated median for the VTT distribution was higher than the mean. The estimated means for business and non-business were given by 18.22 and 28.68 euro per hour, which is already much lower than in the original analysis, though it should be noted that the Latent Class model performed less well in terms of statistical performance than the lognormal model of Koster et al. (2011) (Koster 2023, private communication).
- Differences in the utility function
  - Koster et al. have used a scheduled delay formulation, with coefficients on the amount of time that a respondent arrives earlier or later than his/her preferred arrival time. In our study, we have estimated coefficients on the amount of time that the respondent arrives earlier than the latest time before missing the flight. This might also have led to differences in the resulting VTT.
- Differences in the sample
  - In our study, we used a sample enumeration with weights based on observed national statistics (i.e. the Schiphol Routes & Profile Monitor) to calculate the national average VTT. Koster et al. (2011) calculated their average VTT based on their unweighted sample, which might have led to biases if their sample was not fully representative in unobservables (except for income which was correctly sampled).

It is likely that a combination of all issues mentioned above and in Section 10.2.1 can explain the observed differences, where the misspecification of the lognormal distribution for the VTT might be the most important. Since the results from the current study (1) are plausible, (2) are more recent, (3) are weighted to match national statistics, and (4) are consistent with the methodology used for the VTT of other modes, it is advised to use the values from this study.

11.2 Value of travel time for cycling / walking

11.2.1 Results

To determine the value of travel time for cycling and walking, we have taken the models that were discussed in Section 8.3 and applied these in the sample enumeration that was described in Section 9.1. For every respondent in the sample a value of travel time is calculated. Finally, for each mode and purpose combination a weighted average is calculated. The resulting values of time are presented in Table 43.

Table 43 – Value of travel time for cycling and walking, in € / hr (price level 2022)

Mode	Purpose			
	Commute	Business	Other	All purposes
Cycling	10.17	11.20	10.43	10.39
Walking	15.89	14.72	11.76	11.84

11.2.2 Discussion

Table 43 shows that the VTT for walking is higher than for cycling, indicating that on average travellers find 1 minute of cycling preferable over 1 minute of walking. Furthermore, the table shows that the VTTs do not differ much between purposes. It is remarkable that for walking the VTT for commute trips is larger than for business trips. We have not seen this for any other mode. This is likely to be a self-selection effect: business travellers with a high VTT are more likely to switch to a different (faster) mode, leaving only walking business travellers with a relatively low VTT.

From Table 43, it also becomes clear that the cycling VTT for commute and other purposes is not too different from the VTT for car as reported in Table 29. This is relevant since no official VTT for cycling was available in the Netherlands before this study and some studies have used the car VTT for calculating the benefits for cyclists in cost-benefit analyses. Based on these new results, this seems to have been a reasonable approximation.

Earlier studies that reported a VTT for cycling include studies by Börjesson & Eliasson (2012), Björklund & Mortazavi and Van Ginkel (2014). Their results are summarised in Table 44. All studies report a cycling VTT for cycling paths and for mixed traffic conditions. We calculated the average of these two values and converted these numbers to price level 2022 correcting for (Dutch) inflation. The VTT in our study is lower than was found in Sweden (42% lower than in Börjesson & Eliasson (2012) and 62% lower than in Björklund & Mortazavi (2013). This might be due to cultural differences, differences that are introduced when converting money units, or methodological differences.

The differences with the (Dutch) results from van Ginkel (2014) are smaller: 32% lower for commute and 6% lower for other purposes. These decreases of the VTT are similar to those found for other travel modes in our study, so we believe that these results are consistent.

Table 44 – Value of travel time for cycling from other sources, in € / hr

Study	Country	Study year	VTT cycling Cycle path	VTT cycling Mixed traffic	VTT cycling Average (price level of study year)	VTT cycling Average (price level 2022)
Börjesson & Eliasson (2012)	Sweden	2008	€ 10.50	€ 15.90	€ 13.20	€ 17.94
Björklund & Mortazavi (2013)	Sweden	2011	€ 16.83	€ 25.08	€ 20.96	€ 27.15
Van Ginkel (2014) (commute)	The Netherlands	2013?	€ 9.80	€ 13.40	€ 11.60	€ 14.90
Van Ginkel (2014) (other)	The Netherlands	2013?	€ 7.60	€ 10.30	€9.00	€ 11.10

11.3 Value of travel time for recreational navigation

To determine the value of travel time for recreational navigation, we have taken the model that was discussed in Section 8.4 and applied these to the unweighted sample of respondents from this study, since no national statistics are available to determine other weight factors. For every respondent in the sample a value of travel time is calculated. Finally, the average over all respondents is calculated. The resulting value of time is € 8.07 (Table 45). Note that this VTT is presented at price level 2022, though data was collected in 2021. The cost levels in the SP were corrected for the inflation and 50% of the real income growth between 2021 and 2022.

Table 45 also shows the VTT for recreational navigation as was found in the previous study, both at price level 2010 and price level 2022 after correction for inflation and 50% of the real income growth. The 2022 VTT is 25% lower than the VTT based on the results from the previous study. This percentage is in line with the VTT differences found for other travel modes (see Section 10.2).

Table 45 – Comparison VTT for recreational navigation between the 2022 and 2009/2011 studies

Mode	Purpose	VTT 2022 Price level 2022	VTT 2009/ 2011 Price level 2010	VTT 2009/ 2011 Price level 2022	Difference
Recreational navigation	Other	8.07	8.25	10.69	-25%

12. Uncertainty and sensitivity analysis

12.1 Uncertainty analysis

In order to estimate the uncertainty bandwidth of the VTT results that were presented in the previous chapters, we have investigated the following sources of uncertainty:

1. uncertainty in the estimated model coefficients
2. uncertainty from weight factors used for the sample enumeration
3. uncertainty from heterogeneity among persons in the population used for the sample enumeration
4. uncertainty from the demarcation of the population used for the sample enumeration

In the following subsections we describe the methods used. The resulting uncertainties are presented in Table 47.

12.1.1 Source of uncertainty 1: uncertainty from the estimated model coefficients

The software used for the estimation of the model coefficients also presents uncertainty intervals for each coefficient. However, it is of paramount importance to also take the correlation between the coefficients into account. This is not a simple analysis.

Therefore, we have done the following test. For the car model, we have started with the default Mixed Logit estimation. Next, we have fixed the value of a single parameter lmda_t_vtt to its default model value plus one standard error (as given by the software). We chose this particular parameter because it has a relatively large uncertainty, and it has a potentially large impact on the average VTT (also because the national average VTT is weighted by travel time). After that, the remaining coefficients are re-estimated to take their correlation with the fixed parameter fully into account. Then, the sample enumeration is performed and the difference with the results from the default model are compared. This process is repeated for fixing the lmda_c_vtt parameter which was chosen for similar reasons.

We have executed this test for the car model and determined the average relative effect of uncertainty in the way described above. The resulting uncertainty is relatively low. Since running the mixed logit models takes a considerable amount of time, it is not possible to repeat this for all parameters and all models. Therefore, we have inferred that the relative effect for the other models is the same as for the car model after a correction for the different sample size[23].

The resulting uncertainties are presented in Table 47. It turns out that this source of uncertainty is relatively small.

12.1.2 Source of uncertainty 2: uncertainty from weight factors used for the sample enumeration

To assess the impact of the weighting factors, alternative sets of weighting factors are derived and corresponding weighted average VTTs are calculated. The sets of weighting factors differ in the sequence in which the targets are applied in the IPF procedure. Nine different sequences were generated by random shuffling the default sequence. Note that this test was not performed for recreational navigation since no weight factors are used for this mode.

The relative uncertainty of the VTT (the standard deviation of the series of all VTTs from the different sequences) is presented in Table 47. It turns out that this source of uncertainty is relatively small but with some exceptions.

Note that there is a rationale behind the default sequence: the most important targets are applied last. As a result, the survey population will have the best fit to the target population on the most important targets.

[23] The relative uncertainty in the estimated coefficients is assumed to be proportional to the square root of the number of observations used for modelling.

12.1.3 Source of uncertainty 3: uncertainty from heterogeneity among persons in the population used for the sample enumeration

The uncertainty from heterogeneity is measured as the standard deviation of the mean, approximated from the standard deviation over the persons in the sample enumeration:

$$\sigma_{\overline{VTT}} \approx \sigma_{VTT} / \sqrt{n}$$

The resulting uncertainties are presented in Table 47. It turns out that this source of uncertainty is relatively small.

12.1.4 Source of uncertainty 4: uncertainty from the demarcation of the population used for the sample enumeration

As described in Chapter 9, a set of respondents from both panel and intercept are used for the sample enumeration. Other options would have been to use only the panel respondents or only the intercept respondents. Both options have been explored and result in (slightly) different VTTs, as summarised in Table 46. Note that in the sample enumeration the intercept interaction coefficient for car that was estimated in the joint SP1A/2A-model was not applied. This means that in the sample enumeration the observed increase of the car VTT for intercept respondents (see Section 8.1.2) is not included. Also note that no VTT for air-business could be calculated for the sample enumeration based on the intercept respondents only, due to the low number of respondents that got the WTP instructions in that segment.

Table 46 – VTT from sample enumeration based on intercept+panel / on intercept only / on panel only

	Commute	Business	Other	All
Car	10.78 / 11.37 / 10.11	21.20 / 24.90 / 18.81	9.60 / 9.43 / 9.13	10.42 / 10.55 / 9.83
Train	12.05 / 12.45 / 11.95	17.96 / 14.71 / 18.13	8.64 / 8.57 / 8.38	10.08 / 10.05 / 9.90
Local PT	7.62 / 7.83 / 7.44	14.39 / 9.43 / 14.26	6.66 / 6.85 / 6.47	7.12 / 7.15 / 6.93
Air		110.22 / n.a. / 111.16	53.8 / 59.03 / 52.70	61.79 / n.a. / 61.19
Recr. nav.			8.07 / 8.07 / 8.07	8.07 / 8.07 / 8.07
Bicycle	10.17 / 9.70 / 10.11	11.20 / 12.68 / 11.04	10.43 / 10.81 / 10.62	10.39 / 10.59 / 10.53

The relative uncertainties (calculated by taking the average of the absolute differences of the two options with intercept only and panel only compared to the default option with intercept+panel) are presented in Table 47. It turns out that this source of uncertainty is important compared to other sources of uncertainty.

Note that this test was not performed for walking since no intercept respondents were collected for this mode, so the population used for the sample enumeration for this mode can only be the internet panel population.

12.1.5 Resulting uncertainties

The first four columns of Table 47 summarise the results from the uncertainty analysis as described in the previous four sections. In the fifth column marked “Total” the root-mean-square of the four previous columns is taken. In the last column, the VTT with the uncertainty interval in euros is shown.

In the lower part of the table, the averages over all purposes are displayed. Note that these have smaller bandwidths since they are calculated over more respondents and hence, the uncertainty decreases.

Table 47 – VTT uncertainty bandwidths by source of uncertainty

Mode	Purpose	Source of uncertainty					
		1	2	3	4	Total	
Car	Commute	0.28%	0.53%	0.37%	5.84%	5.89%	10.78 ± 0.63
Car	Business	0.26%	0.70%	1.18%	14.36%	14.43%	21.20 ± 3.06
Car	Other	0.31%	2.39%	0.52%	3.33%	4.15%	9.60 ± 0.40
Train	Commute	0.35%	0.08%	0.41%	2.07%	2.15%	12.05 ± 0.26
Train	Business	0.32%	0.70%	1.89%	9.52%	9.74%	17.96 ± 1.75
Train	Other	0.39%	0.24%	0.46%	1.91%	2.02%	8.64 ± 0.17
Local PT	Commute	0.35%	0.08%	0.52%	2.56%	2.64%	7.62 ± 0.20
Local PT	Business	0.33%	2.59%	1.81%	17.69%	17.97%	14.39 ± 2.59
Local PT	Other	0.40%	0.09%	0.60%	2.85%	2.94%	6.66 ± 0.20
All land modes	Commute	0.19%	0.00%	0.28%	5.20%	5.22%	10.76 ± 0.56
All land modes	Business	0.17%	0.00%	0.87%	11.46%	11.50%	20.63 ± 2.37
All land modes	Other	0.21%	0.00%	0.32%	3.05%	3.08%	9.34 ± 0.29
Air	Business	0.31%	0.80%	1.00%		1.31%	110.22 ± 1.45
Air	Other	0.37%	0.01%	0.39%	5.88%	5.91%	53.80 ± 3.18
Recr. nav.	Other	0.80%	n.a.	0.50%	n.a.	0.94%	8.07 ± 0.08
Cycle	Commute	0.40%	0.70%	0.29%	2.61%	2.74%	10.17 ± 0.28
Cycle	Business	0.37%	2.46%	0.89%	7.32%	7.78%	11.20 ± 0.87
Cycle	Other	0.45%	0.42%	0.48%	2.73%	2.84%	10.43 ± 0.30
Walk	Commute	0.50%	2.33%	0.94%	n.a.	2.56%	15.89 ± 0.41
Walk	Business	0.47%	3.41%	2.38%	n.a.	4.18%	14.72 ± 0.62
Walk	Other	0.56%	0.31%	1.28%	n.a.	1.43%	11.76 ± 0.17
Mode	**Purpose**	**1**	**2**	**3**	**4**	**Total**	
Car	All	0.29%	1.50%	0.58%	3.45%	3.82%	10.42 ± 0.40
Train	All	0.36%	0.25%	0.50%	1.04%	1.23%	10.08 ± 0.12
Local PT	All	0.37%	0.42%	0.56%	1.54%	1.74%	7.12 ± 0.12
All land modes	All	0.19%	0.00%	0.29%	3.24%	3.26%	10.19 ± 0.33
Air	All	0.34%	0.09%	0.50%		0.62%	61.79 ± 0.38
Recr. nav.	All	0.73%	n.a.	0.50%	n.a.	0.89%	8.07 ± 0.07
Cycle	All	0.41%	0.77%	0.29%	1.64%	1.88%	10.39 ± 0.20
Walk	All	0.52%	0.46%	0.84%	n.a.	1.09%	11.84 ± 0.13

12.2 Sensitivity analysis

In the discussion of the interaction coefficients in Chapter 8, we underlined that the dependencies that were found were only under the condition of "all else being equal". To demonstrate what the relation between VTT and the explanatory variables is in practice (i.e. including all correlations with other explanatory variables), we present two examples in this section: the relation between VTT and trip duration and the relation between VTT and income. To determine these relations, we use the sample enumeration and calculate the VTT for each trip duration interval and separately for each income class. Due to the sample nature of this technique, the resulting VTTs per trip duration interval and per income class contain some level of uncertainty, which we also will show.

12.2.1 Dependency on trip duration

Figure 18 shows the average VTT for each BaseTime interval, as calculated in the sample enumeration (provided that we have at least 5 observations in the interval). Error bars are based on the variance of the VTT between the respondents in that BaseTime interval, which may not include all uncertainties.

As can be seen from these figures, the VTT increases with trip duration for car, train and local public transport. For all these modes, the VTT becomes constant for trip durations above approximately 60 minutes. Note that this does not follow directly from the estimated coefficients. In Table 15, we saw that the BaseTime elasticity of the VTT (i.e. `lmda_t_vtt`) for these three modes was never significantly different from zero.

For air, the VTT seems more or less constant for each trip length, despite the BaseTime elasticity of -0.1 as found in the estimation (Table 20). For cycling and walking, we observe a clearly declining VTT up to a trip duration of about 60 minutes. Also in the estimations, we found a negative BaseTime elasticity of -0.26 (cycling) and -0.63 (walking), see Table 21.

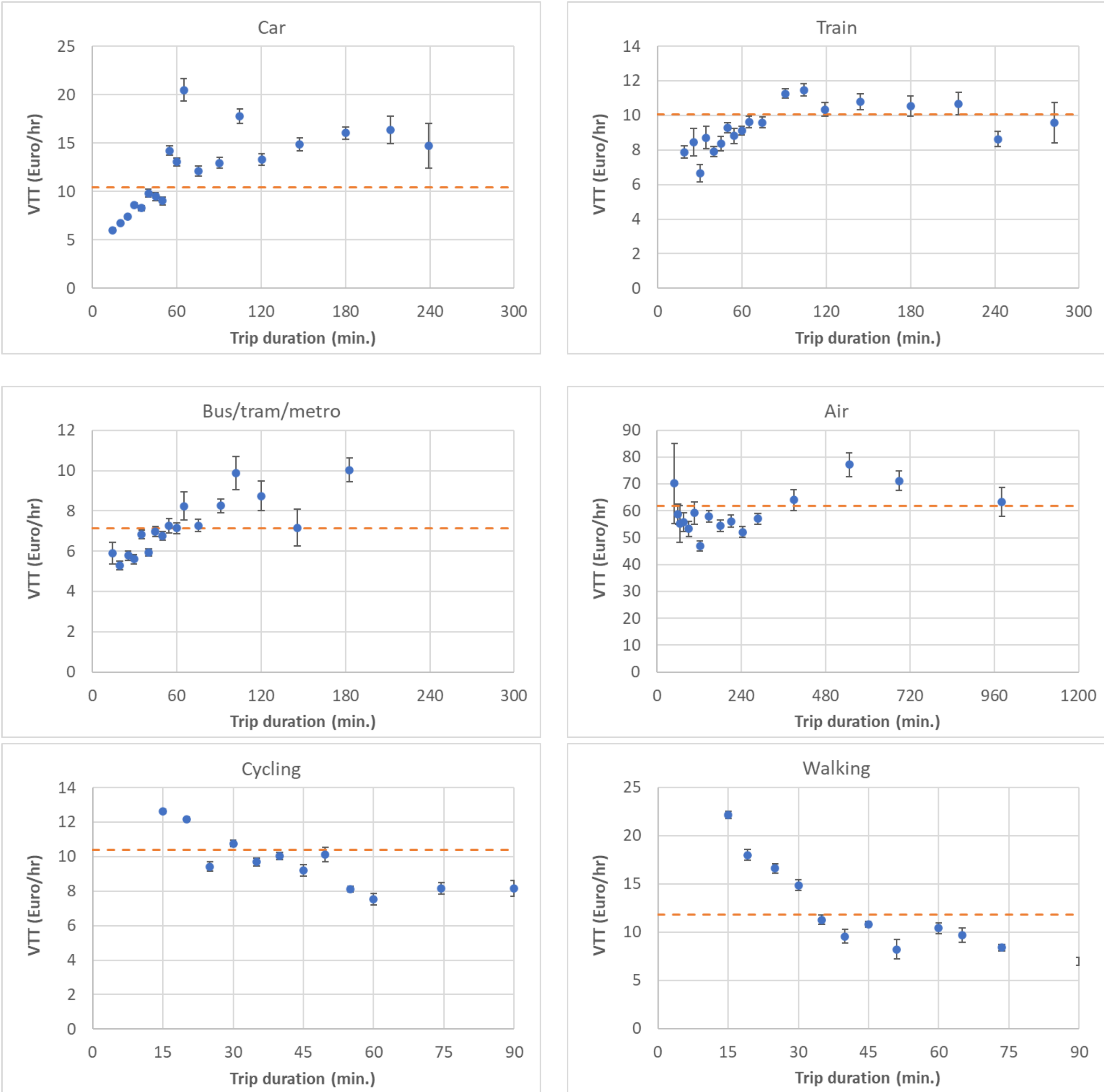


Figure 18 – VTT dependency on trip duration per mode, orange line indicates the average VTT, error bars are based on the variance of the VTT between the respondents within the trip duration interval.

12.2.2 Dependency on income

Figure 19 shows the average VTT for each income interval, as calculated in the sample enumeration (provided that we have at least 5 observations in the interval). Error bars are based on the variation of the VTT between the respondents in that income interval, which may not include all uncertainties.

From these figures, the VTT increases with income for all modes, except for cycling. Additionally, the increase by income is less clear for local public transport and walking then it is for car, air and recreational navigation. In the estimations, we did not find a significant income elasticity for walking and cycling. For all other modes, an income elasticity between about 0.1 and 0.2 was found, which implies that the VTT increases by 7 – 15% for every doubling of the income. Especially for lower incomes, the figures below show that the VTT increases more rapidly than that as a result of the interaction between income and other explanatory variables of the VTT.

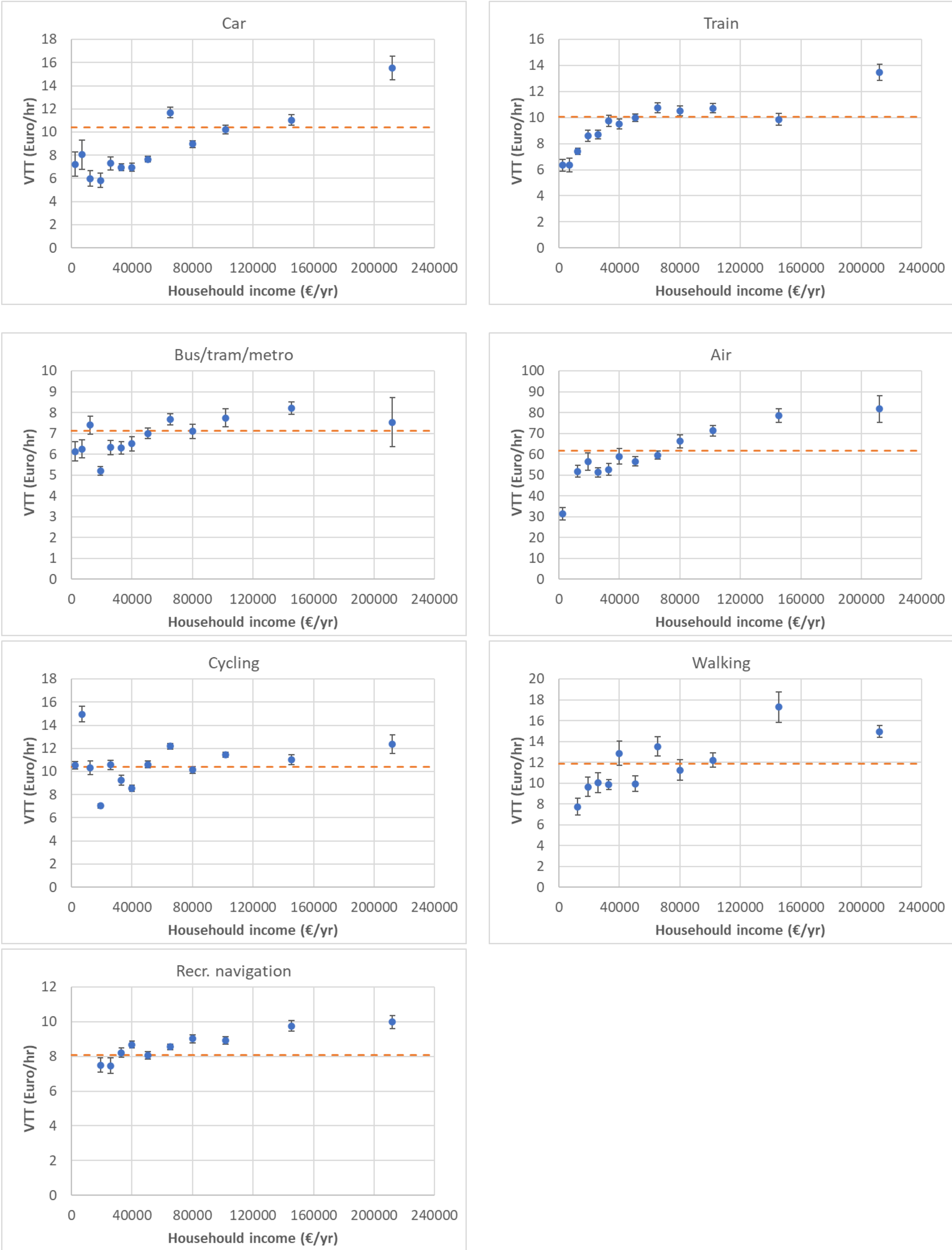


Figure 19 - VTT dependency on income per mode, orange line indicates the average VTT, error bars are based on the variance of the VTT between the respondents within the household income interval.

13. Value of travel time reliability

13.1 Results

As explained in Section 9.2 the reliability ratios for each mode and purpose combination can be derived directly from the estimated model coefficients. The resulting reliability ratios can be found in Table 48. The same table also displays the value of travel time reliability which is obtained by multiplying the VTT (Table 29, Table 41, Table 45) by the reliability ratio.

The values of travel time reliability for all land modes combined and/or for all purposes combined are obtained by calculating the weighted average over the appropriate mode/purpose combinations, using the weights from Table 27 (right-hand side).

Table 48 – Reliability ratios and values of travel time reliability, in € / hr (price level 2022)

Mode	Reliability Ratio				Value of travel time reliability			
	Purpose				Purpose			
	Commute	Business	Other	All	Commute	Business	Other	All
Car	0.27	0.21	0.35	0.32	2.91	4.45	3.36	3.32
Train	0.32	0.11	0.27	0.27	3.86	1.98	2.33	2.76
Local public transport	0.65	0.61	0.56	0.59	4.95	8.78	3.73	4.17
Land modes (motorised)	0.30	0.21	0.35	0.33	3.18	4.38	3.28	3.31
Air	-	0.30	0.28	0.28	-	33.07	15.06	17.60
Recr. navigation	-	-	0	0	-	-	0.00	0.00

13.2 Discussion

The reliability ratios found in this study are clearly lower than the ones found in the 2009/2011 study, especially for business trips made by car or by train (Table 49). However, they are much more in line with reliability ratios as found in the national studies in Norway 2018 (Flügel et al., 2020) Norway 2010 (Ramjerdi et al. 2010) and UK 2014 (Batley at al., 2019), so it seems that the reliability ratios as found in the previous study might have been relatively high.

Table 49 – Comparison reliability ratios between the 2022 and 2009/2011 studies

Mode	Purpose	This study	NL-2009/2011	Absolute difference	Relative difference
Car	Commute	0.27	0.4	-0.13	-33%
	Business	0.21	1.1	-0.89	-81%
	Other	0.35	0.6	-0.25	-42%
Train	Commute	0.32	0.4	-0.08	-20%
	Business	0.11	1.1	-0.99	-90%
	Other	0.27	0.6	-0.33	-55%
Bus, tram, metro	Commute	0.65	0.4	+0.25	+63%
	Business	0.61	1.1	-0.49	-45%
	Other	0.56	0.6	-0.04	-7%
Air	Business	0.30	0.7	-0.40	-57%
	Other	0.28	0.7	-0.42	-60%
Recr. Navigation	Other	0	0	-	-

Table 50 – Comparison of reliability ratios between the 2022 study and national studies in Norway and the UK

Mode	Purpose	This study	Norway 2018	Norway 2010	UK 2014
Car	Commute	0.27	0.4	0.25 (long) – 0.42 (short)	0.33
	Business	0.21	0.4		0.42*
	Other	0.35	0.4		0.35
Train	Commute	0.32	0.4	0.54 (long)	-
	Business	0.11	0.4		-
	Other	0.27	0.4		-
Bus, tram, metro	Commute	0.65	0.4	0.69 (short)	-
	Business	0.61	0.4		-
	Other	0.56	0.4		-
Air	Business	0.30	-	0.20 (long)	-
	Other	0.28	-		-
Recr. Navigation	Other	0	-	-	-

* only applies to employee part of the VTT

Indeed, there are some clear differences between the method with which the reliability ratios were determined in this study and in the previous study:

- The presentation of the alternatives was different: in the 2009/2011 experiment SP2b four attributes were presented: the travel cost, the most common (median) travel time, five possible travel time and the departure time (Figure 20, left). The departure time (and arrival time) were not included in the modelling. In the 2022 study, no departure and arrival times were presented (Figure 20, right).
- In the 2009/2011 study, the average travel time was used in the modelling, while this was not explicitly presented to the respondents. The most common (median) travel time that was presented was not used in the modelling. It was assumed that the respondents had ignored the most common travel time and had calculated the average travel time from the of the five possible travel times. For instance, in the “Rit A” alternative in Figure 20 (left), the average travel time over the five possible travel times is 45 minutes, which is 10 minutes larger than the most common travel time that is presented. It is likely that this presentation and this interpretation has led to confusion between the value of travel time and the value of travel time reliability. Hence, the resulting reliability ratios from the 2009/2011 study might suffer from a bias.

- In the 2009/2011 analysis, only the intercept respondents (recruited in 2011) were used to determine both the value of travel time and the value of travel time reliability. For car, we have seen in this survey that this might lead to an increased value of travel time. It is possible that the focus on intercept respondents only also has led to an increase in the reliability ratio.
- In the 2009/2011 analysis, the number of intercept respondents used for the estimation was limited, resulting in large uncertainty ranges. The t-ratios for the RR for commute, business and other were respectively 2.2, 6.8 and 1.3. It is striking that the t-ratio for business is still the largest, indicating the most precise determination of the RR, while for car-business and train-business the largest difference with the 2022 results were found (Table 49). This might just be a statistical coincidence in both the 2009/2011 study and in the 2022 study (note that the 2022 results for these two mode/purpose combinations are relatively low compared to the values found in Norway (see Table 50)).
- Especially for business trips, the methodology used in the 2009/2011 study differed from the one used in the 2022 study. In 2009/2011, respondents received instructions consistent with the Hensher-equation method ("assume you are making this trip in your own time / at your own cost"), so the reliability ratio only applies to the employee part of the business VTT. In the 2022-study, respondents received instructions consistent with the WTP-method ("take the interests of your employer also into account when making your choices"), so the resulting reliability ratio applies to both the employer and the employee part of the business VTT. This might explain in part why in 2022 a lower RR was found.

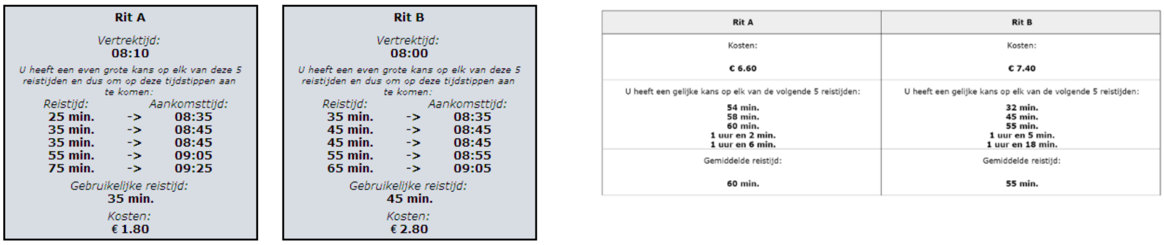


Figure 20 – Reliability SP experiment in the 2009/2011 study (left) and in the 2022 study (right)

The reliability ratios found in this study are clearly lower than the ones found in the 2009/2011 study, especially for business trips made by car or by train (Table 49). However, they are much more in line with reliability ratios as found in the national studies in Norway 2018 (Flügel et al., 2020) Norway 2010 (Ramjerdi et al. 2010) and UK 2014 (Batley at al., 2019), so it seems that the reliability ratios as found in the previous study might have been relatively high.

Given the clear differences between the method with which the reliability ratios were determined in this study and in the previous study, and given that the new reliability ratios are much more in line with reliability ratios as found in the national studies in Norway 2010, Norway 2018 and UK 2014, it can be concluded that the new values are more plausible than the ones from the previous study, and that is recommendable to use the new values.

14. Multipliers

14.1 Multipliers for cycling / walking path quality factors

As explained in Section 9.3, multiplies can be determined directly from the estimated coefficients. No sample enumeration is necessary.

The resulting factors are presented as a multiplier on the value of travel time for cycling and walking. (Note that these values of travel time are determined in experiment SP1B). VTT multipliers for quality factors of cycling routes can be found in Table 51, and for walking routes in Table 52. The multipliers are calculated with respect to their average quality level which corresponds to the average quality level obtained from the sample enumeration. This ensures that the VTTs for walking and cycling derived from SP1B are consistent with the quality multipliers that are derived from SP2B. The weights for each attribute level that are used to ensure that the average multiplier is 1 are also displayed in the tables.

An multiplier below 1 indicates that a route is more comfortable or more convenient. This multiplier lowers the value of travel time. After all, if people like a certain route, there is less need for them to shorten the travel time. In economic terms: they have a lower “willingness-to-pay” for a shorter route. Or vice versa: if a route is very uncomfortable, people assign a higher value to a reduction of the travel time, which leads to a multiplier above 1. Multipliers for different quality aspects of the route may be multiplied with each other to get the total VTT multiplier for a route.

From both tables it follows that all multipliers have the expected size with respect to the other levels of the same attribute. Only the walking path multiplier for configuration 7 (walking path next to a cycling path without other traffic) is lower than for configuration 8 (walking path without cyclist and other traffic), indicating that pedestrians prefer the presence of cyclists. This was not expected a-priori. However, it might be that pedestrians consider their walking path to be more safe if more other people are present. Also note that the difference between both multipliers is very small, so it might just be a statistical coincidence.

Very few other sources on the valuation of quality aspects of cycling and walking routes are available. Table 44 shows that in Sweden a multiplier for mixed traffic cycling routes of about 1.5 was found compared to a cycling path. For the similar route comparison, Van Ginkel found a multiplier of about 1.36 for the Netherlands. Our study does not provide exactly the same route specifications. If we take the (unweighted) average of the multipliers for the first seven configurations (all with some car interactions), we get a multiplier of 1.06, which is 22% higher than the multiplier for configuration 8 (stand-alone cycling path). The worst valued configuration (configuration 2, road with mix of cars and cyclist, where cars are allowed to drive 50 km/h) has a multiplier which is 43% higher than that for the best valued configuration (i.e. the stand-alone cycling path). All these multiplier differences have the same order-of-magnitude as the ones shown in Table 44.

Table 51 – VTT multipliers for quality factors of cycling routes

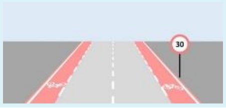
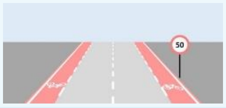
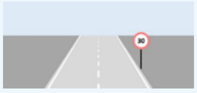
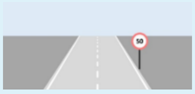
Attribute	Level	Description (Dutch / English)			Multiplier	Weight
Cycling path configuration	1	*Gedeelde weg met auto's (30 km/u)* Car road – bikes allowed (30 km/h)			1.085	*5.41%*
	2	*Gedeelde weg met auto's (50 km/u)* Car road – bikes allowed (50 km/h)			1.233	*12.89%*
	3	*Fietsstraat (auto's toegestaan, voorrang voor fietsers, 30 km/u)* Bike street – cars allowed, bikes have priority (30 km/h)			0.956	*3.64%*
	4	*Fietsstrook met onderbroken streep (30 km/u)* Bike lane in the road (30 km/h)			0.993	*4.31%*
	5	*Fietsstrook met onderbroken streep (50 km/u)* Bike lane in the road (50 km/h)			1.034	*7.84%*
	6	*Vrijliggend fietspad langs een weg (50 km/u)* Bike lane next to the road (50 km/h)			0.963	*20.71%*
	7	*Vrijliggend fietspad langs een weg (80 km/u)* Bike lane next to the road (80 km/h)			1.122	*13.37%*
	8	*Vrijliggend fietspad (zonder andere weg in de buurt)* Bike path (no other road around)			0.862	*31.84%*
	Average (weighted)				1.000	
Type of pavement	1	*Klinkers*	Paving stones		1.183	*3.62%*
	2	*Stoeptegels*	Sidewalk tiles		1.169	*9.37%*
	3	*Betonplaten*	Concrete slabs		1.085	*2.17%*
	4	*Asfalt*	Asphalt		0.971	*84.83%*
	Average (weighted)				1.000	
Amount of bypassing cars for cycling path configuration 1 – 5	1	*Zeer weinig*	Very few		0.944	*14.78%*
	2	*Weinig*	Few		0.956	*60.93%*
	3	*Veel*	Many		1.139	*23.00%*
	4	*Zeer veel*	Very many		1.264	*1.28%*
	Average (weighted)				1.000	
Amount of bypassing cars for cycling path configuration 6 - 7	1	*Zeer weinig*	Very few		0.934	*7.64%*
	2	*Weinig*	Few		0.963	*46.18%*
	3	*Veel*	Many		1.037	*41.98%*
	4	*Zeer veel*	Very many		1.149	*4.19%*
	Average (weighted)				1.000	
Beautifulness of route	1	*Zeer mooi*	Very beautiful		0.932	*21.20%*
	2	*Mooi*	Beautiful		0.949	*58.31%*
	3	*Niet mooi*	Not beautiful		1.209	*18.41%*
	4	*Helemaal niet mooi*	Absolutely not beautiful		1.285	*2.07%*
	Average (weighted)				1.000	

Table 52 - VTT multipliers for quality factors of walking routes

Attribute	Level	Description		Multiplier	
Walking path configuration	1	*Lopen op weg waar ook auto's en fietsers rijden, geen apart voetpad (30 km/u)* Walking on road with cars and bikes, no pedestrian path (30 km/u)		1.397	*2.41%*
	2	*Lopen op weg waar ook auto's en fietsers rijden, geen apart voetpad (50 km/u)* Walking on road with cars and bikes (50 km/u) , no pedestrian path		1.598	*4.38%*
	3	*Stoep direct langs weg waar fietsers en auto's rijden (30 km/u)* Sidewalk directly next to road with cars and bikes (30 km/u)		1.100	*16.13%*
	4	*Stoep direct langs weg waar fietsers en auto's rijden (50 km/u)* Sidewalk directly next to road with cars and bikes (50 km/u)		1.192	*12.66%*
	5	*Stoep op 2 meter langs weg waar fietsers en auto's rijden (30 km/u)* Sidewalk at 2 metres from road with cars and bikes (30 km/u)		1.005	*4.17%*
	6	*Stoep op 2 meter langs weg waar fietsers en auto's rijden (50 km/u)* Sidewalk at 2 metres from road with cars and bikes (50 km/u)		1.034	*14.05%*
	7	*Vrijliggend fiets/voetpad (geen autoverkeer)* Shared bike/pedestrian path (no car traffic)		0.818	*26.51%*
	8	*Vrijliggend voetpad (geen autoverkeer)* Pedestrian path (no car traffic)		0.832	*19.69%*
	Average (weighted)			1.000	
Walking path width	1	Smal pad (minder dan 1 m breed) met obstakels (geparkeerde fietsen, bloembakken etc.) Narrow path (less than 1 m) with obstacles (parked bikes, flower beds etc.)		1.072	*8.90%*
	2	Smal pad (minder dan 1 m breed) zonder obstakels Narrow path (less than 1m) without obstacles		1.008	*6.56%*
	3	Normaal pad (1 tot 2 m breed) Normal path (1 – 2m wide)		0.997	*75.53%*
	4	*Breed pad (meer dan 2 m breed, boulevard-achtig)* Wide path (more than 2m wide, boulevard-like)		0.952	*9.01%*
	Average (weighted)			1.000	
Amount of bypassing cars for walking path configuration 1 or 2	1	*Zeer weinig*	Very few	0.845	*0.49%*
	2	*Weinig*	Few	0.937	*59.05%*
	3	*Veel*	Many	1.094	*40.46%*
	4	*Zeer veel*	Very many	1.080	*0.00%*
	Average (weighted)			1.000	
Amount of bypassing cars for walking path configuration 3 - 6	1	*Zeer weinig*	Very few	0.914	*21.04%*
	2	*Weinig*	Few	0.937	*42.45%*
	3	*Veel*	Many	1.113	*32.96%*
	4	*Zeer veel*	Very many	1.211	*3.54%*
	Average (weighted)			1.000	
Beautifulness of route	1	*Zeer mooi*	Very beautiful	0.932	*27.62%*
	2	*Mooi*	Beautiful	0.947	*56.28%*
	3	*Niet mooi*	Not beautiful	1.277	*11.81%*
	4	*Helemaal niet mooi*	Absolutely not beautiful	1.374	*4.30%*
	Average (weighted)			1.000	

14.2 Multipliers for public transport trip components

14.2.1 Results

As explained in Section 9.2, the public transport trip component multipliers for each mode and purpose combination can be derived directly from the estimated model coefficients. The resulting multipliers are presented in Table 53.

Table 53 - VTT multipliers for public transport trip components

Multiplier	Train	Local PT
Access/egress time multiplier	1.11	1.03
Wait/transfer time multiplier	0.95	0.72
Number of transfer	11.30	12.24

We note that the access/egress time multipliers are not significantly different from one. The (one-sigma) uncertainty margin for train and local public transport is 0.12 and 0.11 respectively. This implies that the value of one falls easily within the 95% confidence interval (i.e. 1.96 times the one-sigma uncertainty margin).

The same is true for the wait and transfer time multipliers. For those parameters, the (one-sigma) uncertainty margin for train and local public transport is 0.13 and 0.18 respectively. Again, this implies that the value of one falls within the 95% confidence interval.

14.2.2 Discussion

Table 54 shows walk time multipliers, transfer time multipliers, wait time multipliers and transfer penalties as they are published by other sources.

- In 2014, the international transport forum (ITF) at OECD organised a round table discussion with experts on "valuing convenience in public transport". As the chairman, Mark Wardman wrote an extensive paper on the summary and conclusions. This paper[24] contains a table (Table 2) with the multipliers that are found in several meta studies in which the results from a large number of individual studies are combined. This table is summarised in Table 54. Full details can be found in the original paper.

  The same paper also had a table (Table 1) on the official multipliers that are used in countries for e.g. cost-benefit analysis. Here, also walk and wait multipliers of 1 can be found, e.g. for Germany, Norway and Chili, but it is noted that these countries use door-to-door time with all trip components having the same weight.

- In the UK, the Transport analysis guidance (TAG)[25] writes that "The various components of generalised cost are weighted in order to reflect the perceived time spent at each step of the public transport journey. IHT's Guidelines on Developing Urban Transport Strategies (May 1996) and ITS and John Bates's review of value of time savings in the UK in 2003 suggest:
  - value of walk time = 1.5 to 2.0 times in-vehicle time
  - value of wait time = 1.5 to 2.5 times in-vehicle time
  - interchange penalty = 5 to 10 minutes of in-vehicle time per interchange

- The Appraisal Vademecum, published in 2021 by the Directorate-General for Regional and Urban Policy of the European Commission, provides "detailed advice on door-to-door perceived time

[24] https://www.oecd-ilibrary.org/transport/valuing-convenience-in-public-transport_9789282107683-en

[25] TAG Unit M3.2 (2020) on Public Transport assignment, available via https://www.gov.uk/guidance/transport-analysis-guidance-tag

treatment".[26] They advise to use walk and wait time multipliers between 1.5 and 2 and a transfer penalty between 4 and 15 minutes, based on Wardman and Hine, 2000 and Wardman et al., 2012. These results are also included in the OECD paper by Wardman mentioned above.

- The Dutch national transport model LMS uses the concept of generalised journey time with multipliers for the travel time components for the access and egress trips. These multipliers are purpose-specific, and the ranges of multipliers between purposes are shown in Table 54. Some of these multipliers were estimated on observed data, others were taken from the literature.
- The public transport route assignment in the Flanders 4G- works with perceived journey times, for which the multipliers that are displayed in Table 54. These values were estimated quite some years ago and were adapted since to make sure that the sensitivity of the model towards changes in these travel time components were plausible (based on expert judgement).
- For the ANTONIN transport model for the Île-de-France region, public transport component multipliers are being used. In the ANTONIN-3 version, the multipliers are estimated based on observed route choice data, see Table 54. For the latest version (ANTONIN-4, from 2023 onwards), these multiplier are being re-evaluated. Especially the high transfer penalty values result in a system that is not sensitive to time and frequency changes, which is considered not being plausible.
- Multipliers for the Swiss National Model NMTP were estimated in 2015 based on a combination of observed (RP) and hypothetical (SP) data. The multipliers mentioned in Table 54 were reported.[27]

Table 54 - Comparison of VTT multipliers for public transport trip components between the 2022 study and other sources

	This study	OECD-ITF meta-analyses	WebTAG M3.2 (UK)	Vade-mecum (EU)	LMS-model (NL)	Flanders 4G-model (Belgium)	ANTONIN model (France)	NMTP (Switser-land)
Walk time	1.03 – 1.11	1.66 – 1.93	1.5 – 2	1.5 – 2	1.3 – 1.8	1.7	1.32 – 1.56	1.2
Transfer time	0.72 – 0.95	1.72 – 1.93			1.5	2.5	-	-
Wait time		1.47 – 1.93	1.5 – 2.5	1.5 – 2	1.5	-	1.38	0.97
Transfer penalty	11.30 – 12.24 min.		5 – 10 min.		3.8 min.	3.0 min.	3.0 – 20 min.	5.1 min.

The multipliers for access/egress and for the total wait and transfer time that are found in our study are low compared to similar multipliers values found in other sources (except for the Swiss source), as can be seen from Table 54, though we have to note that these other sources usually refer to a walk time multiplier, while ours applies to more generic access and egress time, and the other sources usually distinguish separate multipliers for transfer and wait time which in our study is combined.

On the other hand, the multiplier for the number of transfers in our study is relatively high compared to the other sources.

The relatively low access/egress and wait/transfer time multiplier in our study suggest that respondents may have simply added these three times together to get the total travel time, without distinguishing between the component. Maybe, this is due to the way the attributes were presented (Figure 9) and/or due to the complexity of the experiment.

A critical review of our SP3 experiment revealed that the partitioning of the recent trip into the three component might not have been clear enough for the respondents. In several cases the sum of the duration of the three components that respondents specified did not add up to the total trip time that they also specified earlier in the survey. Before the SP3A experiment was started, some of these numbers were corrected automatically to get to the correct total time (around which the attribute values were

[26] https://jaspers.eib.org/knowledge/publications/economic-appraisal-vademecum-2021-2027-general-principles-and-sector-applications

[27] Analyse der SP-Befragung 2015 zur Verkehrsmodus- und Routenwahl, Bundesamt für Raumentwicklung ARE https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/grundlagen/analyse-der-sp-befragung-2015-zur-verkehrsmodus-und-routenwahl.html

pivoted), but this correction might not have been correct. This might have let to unrealistic base values for the reference trip in the SP, and that might have led to unrealistic values in the choice tasks. This could be the reason that respondents have focused on the total trip time rather than on the (unrealistic) times of the components.

The possible confusion that respondents might have had in combination with the results that deviate from those published by several independent other sources, leads to the conclusion that our results are not sufficiently solid. Therefore, we recommend that they should not be used as official multipliers in the Netherlands.

14.3 Multipliers for public transport crowding

14.3.1 Results

The crowding multipliers follow from the estimated model coefficients. The resulting multipliers are presented in Table 55 and Table 56 and are displayed in Figure 21 (with occupancy level = 200% corresponding to crowding level 8).

Table 55 - VTT multipliers for public transport crowding levels for train

Train **Crowding levels**	**Multipliers with respect to lowest crowding level**		**Multipliers with respect to average in-vehicle travel time** (i.e. normalised)		**How often did each crowding level occur in the survey**	
	Sit	Stand	Sit	Stand	Sit	Stand
1: 25% of the seats are occupied, nobody is standing	1.00		0.93		*20.7%*	
2: 50% of the seats are occupied, one or two are standing	1.00		0.93		*31.8%*	
3: 75% of the seats are occupied, a few people are standing	1.00		0.93		*17.7%*	
4: Almost 100% of the seats are occupied, a few people are standing	1.00	1.76	0.93	1.63	*12.4%*	*0.9%*
5: 100% of the seats occupied, there are people standing everywhere (1 person per square meter)	1.18	1.93	1.09	1.79	*8.0%*	*1.1%*
6: 100% of the seats occupied, there are people standing everywhere (2 people per square meter)	1.36	2.11	1.26	1.96	*1.8%*	*2.0%*
7: 100% of the seats occupied, there are people standing everywhere (3 people per square meter)	1.53	2.29	1.42	2.12	*0.9%*	*0.9%*
8: 100% of the seats occupied, there are people standing everywhere (4 people per square meter)	1.71	2.47	1.59	2.29	*0.9%*	*1.0%*
Average (weighted)	1.08		1.00			

Table 56 - VTT multipliers for public transport crowding levels for local public transport

Local public transport	Multipliers with respect to lowest crowding level		Multipliers with respect to average in-vehicle travel time (i.e. normalised)		How often did each crowding level occur in the survey	
	Sit	Stand	Sit	Stand	Sit	Stand
1: 25% of the seats are occupied, nobody is standing	1.00		0.97		*20.7%*	
2: 50% of the seats are occupied, one or two are standing	1.00		0.97		*31.8%*	
3: 75% of the seats are occupied, a few people are standing	1.00		0.97		*17.7%*	
4: Almost 100% of the seats are occupied, a few people are standing	1.00	1.12	0.97	1.09	*12.4%*	*0.9%*
5: 100% of the seats occupied, there are people standing everywhere (1 person per square meter)	1.04	1.27	1.01	1.23	*8.0%*	*1.1%*
6: 100% of the seats occupied, there are people standing everywhere (2 people per square meter)	1.08	1.43	1.05	1.38	*1.8%*	*2.0%*
7: 100% of the seats occupied, there are people standing everywhere (3 people per square meter)	1.12	1.58	1.09	1.53	*0.9%*	*0.9%*
8: 100% of the seats occupied, there are people standing everywhere (4 people per square meter)	1.16	1.73	1.13	1.67	*0.9%*	*1.0%*
Average (weighted)	1.03		1.00			

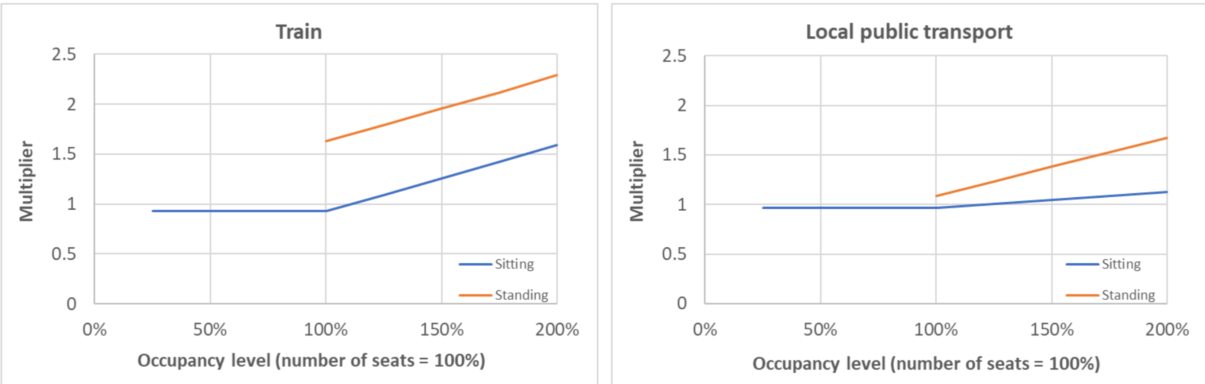


Figure 21 – (normalised) VTT multipliers for public transport crowding levels

14.3.2 Discussion

Table 57 presents crowding multipliers as found in the international literature and as summarised by Wardman (2013). The values found in the UK mainly apply to rail and are consistent with the results from our study for train. The values found in Paris mainly apply to local public transport (including short-distance rail) and are consistent with the values found in our study for local public transport. Given this similarities, there is no indication that the results in our study are affected (i.e. increased) as a result of the recent Covid-19 pandemic.

Table 57 - VTT multipliers for public transport crowding levels as found in other sources

Public transport (generic) **Crowding levels**	**Wardman & Wheeler (2011)** UK		**PDFH (ATOC, 2013)** UK		**Haywood & Koning (2013)** Paris		**Kroes et al. (2013)** Paris	
	Sit	Stand	Sit	Stand	Sit	Stand	Sit	Stand
1: 25% of the seats are occupied, nobody is standing								
2: 50% of the seats are occupied, one or two are standing	0.82							
3: 75% of the seats are occupied, a few people are standing	0.90							
4: Almost 100% of the seats are occupied, a few people are standing	1.00	1.54	1.00	1.34-1.77	1.00		1.083	
5: 100% of the seats occupied, there are people standing everywhere (1 person per square meter)	1.10	1.71	1.09-1.24	1.56-1.81	1.00		1.165	1.289
6: 100% of the seats occupied, there are people standing everywhere (2 people per square meter)	1.21	1.90	1.18-1.48	1.69-1.88		1.05	1.248	1.394
7: 100% of the seats occupied, there are people standing everywhere (3 people per square meter)	1.33	2.10	1.27-1.72	1.82-2.16		1.26	1.330	1.499
8: 100% of the seats occupied, there are people standing everywhere (4 people per square meter)	1.48	2.33	1.36-1.96	1.92-2.43		1.40	1.413	1.604

14.4 Equivalent travel time for the additional time at an airport and the probability of missing a flight

In experiment SP5A the additional time at an airport and the probability of missing a flight were also attributes. Dummy parameters were estimated for each of their levels and these parameters can be interpreted as equivalent travel times. Their values can be found directly in the results from the estimations in Table 20, but for reasons of clarity and completeness, they are repeated here.

Table 20 shows that the equivalent air travel time numbers for the additional time at the airport (compared to the latest possible arrival time at the airport, beyond which you are guaranteed to miss your flight) is always negative. This is since people prefer to have more than 5 minutes additional time, which was used as the reference level. Respondents consider 90 minutes additional time at the airport as optimal. In Table 58 the equivalent travel time is shown for the time at the airport levels compared to the optimal situation of 90 minutes at the airport.

Table 58 – Equivalent air travel time for the amount of additional time at the airport

Additional time at the airport	Compared to 90 minutes at the airport	Equivalent air travel time
5 minutes	85 minutes less	5h 49m more
30 minutes	60 minutes less	3h 24m more
60 minutes	30 minutes less	1h 53m more
90 minutes	-	-
120 minutes	30 minutes more	1h 07m more
150 minutes	60 minutes more	1h 44m more
180 minutes	90 minutes more	2h 40m more

Table 20 shows that the equivalent air travel time numbers for the probability of missing a flight is always positive. This is since people prefer to have a lowest probability as possible. A probability of 1 in 1000 was used as the reference level, and all other levels refer to a higher probability of missing a flight. Therefore, those levels are valued negatively but since they are estimated in equivalent air travel time, the coefficients become positive (one hour air travel time is valued negatively as well). Table 59 shows the equivalent travel time for the probability of missing a flight compared to the optimal situation (in the experiment) of a chance of 1 in 1000.

Table 59 – Equivalent air travel time for the probability of missing a flight

Probability of missing a flight	Compared to a probability of 1 in 1000	Equivalent air travel time
1 in 1000	-	-
1 in 500	1 in 1000 higher probability	0h 21m more
1 in 200	4 in 1000 higher probability	0h 57m more
1 in 100	9 in 1000 higher probability	1h 46m more
1 in 50	19 in 1000 higher probability	3h 10m more

15. Value of transport time for freight

15.1 Introduction

Before the start of this study, it was decided that for freight transport there would be no new SP data collection. Within this study, a cost-effective method was developed to produce representative VTTF (= value of transport time in freight transport) and VTTRF (= value of transport time reliability in freight transport) using new factor costs, but without new SP data. This new factor cost data was collected in a separate project.

The segments that should be distinguished are (as in the 2010 study):

- Road transport (container and non-container)
- Rail transport (container and non-container)
- Air transport (non-container)
- Inland waterway transport (container and non-container)
- Sea transport (container and non-container)

15.2 Typology of decision-makers and transport time benefits in freight

The decision-maker in passenger travel is, in most cases, the traveller himself or herself or a group of travellers. In freight transport the goods cannot decide; different persons may be involved in decision-making at various stages. The shipping firms (producers or traders of commodities) have a demand for transport services, in most cases for sending the products to their clients (in some cases the transport is organized by the receiver). Part of this demand is met by shippers themselves (own account transport). The remainder is contracted out to carrier firms or intermediaries (hire and reward transport). Important choices in transport, such as the choice of mode, can be made by managers of the shipping firm, the carrier and/or the intermediaries. Interviews in the transport market have indicated that for mode choice the shipping firm is the most important decision-maker. Route choice is mainly determined by the managers of the firm carrying out the transport. In the case of road transport, lorry drivers may have some freedom to choose the route or to change route as a reaction to unexpected events (e.g., congestion).

There is considerable heterogeneity in passenger transport, but even more in freight transport. The size of the shipment may vary from a parcel delivered by a courier to the contents of an oil tanker. The value of a truckload of sand is vastly different from a load of gold blocks with the same weight. This does not imply that the value of freight travel time is so heterogeneous that it cannot be established. Heterogeneity can be taken into account by applying a proper segmentation (e.g., by mode, type of good) and proper scaling (e.g., using a value for a typical shipment size or a value per tonne).

The value of freight travel time can include several components, such as:

- Components related to the transport services. These relate to the driver and the transport equipment; drivers are paid for their time and equipment must be leased (or, equivalently, bought and depreciated). A carrier incurs these costs irrespective of what is being carried or even whether the vehicle is loaded. It is not (strongly) commodity specific. Higher productivity in the transport operation ought to lower costs, so if the time taken to complete the delivery reduces, then so should the cost of transport.
- Components related to the cargo. These relate much more to the contents of the shipment, its value, its depreciation, its tendency to degrade, its risk of being stolen and to the wider logistic system that the transport operation is part of. These aspects can also be relevant for the VTTRF. Thus, the value of the product itself and its perishability play a part, but so does the context in which the product is needed within a wider production chain, and the extent to which a supplier needs to accelerate the transport process to meet a customer's delivery terms. Therefore, there can be cases where shippers

will pay a premium for a faster service; less time taken, the higher the value-added for the consignor or consignee.

Unfortunately, there is no universal definition for the VTTF. Not every study includes the same components in the VTTF. Most commonly, one of the following two definitions are used:

- **Narrow definition**: include the transport services components (i.e. the benefits of cargo time saved) in the VTTF, but exclude the carrier components (i.e. the transport cost savings) from the VTTF.
- **Broad definition**: include both cargo components (i.e. cargo time savings) and the carrier components (vehicle time savings, crew time savings, and medium to long run-savings on company overheads, such as administration and office costs) in the VTTF. Only cost savings related to distance (such as fuel costs) are not included in the VTTF.

15.3 Including freight transport time benefits in project appraisals

Transport time savings, certainly in the long run, lead to reductions in the costs of transport staff and transport vehicles, as well as savings that are related to the goods themselves (reduction of the interest on the capital that is invested in the goods during the time of the transport, but also being out of stock). Since there are two definitions for the VTTF, there are also two approaches to include time benefits in a cost-benefit analysis (CBA):

- **Approach A**: when the narrow definition of the VTTF is used, the cargo benefits for the shipper are included in the CBA by multiplying the time savings with the VTTF. The transport service benefits (such as the impacts of projects on staff and vehicle time saved) need to be included in the CBA separately through the transport cost savings (together with the distance-based cost, such as energy and access cost).
- **Approach B**: when the broad definition of the VTTF is used, the benefits for both the cargo and the transport services are included by multiplying the time savings with the VTTF. Only the distance-based cost savings need to be included separately.

This is also depicted in Table 60.

Table 60 - Approaches to time/cost benefits in CBA

CBA component:	Approach A	Approach B
Benefits from transport time savings	Transport time saved × $VTTF_{narrow}$ This includes benefits from: ▪ cargo time saved	Transport time saved × $VTTF_{broad}$ This includes benefits from: ▪ cargo time saved ▪ staff time saved (crew and overheads) ▪ vehicle time saved
Transport cost savings	Transport cost saved This should have the following components: ▪ distance cost saved (energy and access charges) ▪ staff cost saved (crew and overheads) ▪ vehicle cost saved	Transport cost saved This should have the following components: ▪ distance cost saved (energy and access charges)

Both approaches are internally consistent and comply with the requirements that there should not be components missing and there should not be any double counting. Different countries use different systems (e.g., Sweden and Norway use A and The Netherlands uses B (KiM, 2013); in the UK, WebTAG, now TAG, only includes the transport staff cost savings in the VTTF) to freight benefits in CBA. However, in some project appraisals, transport cost savings have been interpreted in a broad fashion and time savings as well, including staff and vehicle time savings in both and thus doing double-counting (i.e. in this case the two approaches mentioned in Table 60 are mixed, which should never be done). For the appraisal of freight transport projects in the Netherlands we recommend (to continue with) option B, since in these projects there is some focus on time (and reliability) benefits and these are collectively captured in the VTTF.

15.4 The Dutch study of 2009-2011

In Significance et al. (2013) VTTF and VTTRFs were sought that include both components (not just the cargo but also the transport services component), since in CBAs for transport projects in The Netherlands the user benefits of savings in vehicle and staff cost are included in the time savings of the project. Previous studies have not tried to disentangle the two VTTF (and VTTRF) components, but this study obtained estimates for both components separately.

A difficult issue in SP surveys on VTTF and VTTRF is who to interview on what. In Significance et al. (2013) specific assumptions (*a priori* hypotheses) were made on the extent to which particular actors take into account different components of the VTTF – and should do so, when responding to the SP questions (see Table 61).

Table 61 - Hypotheses on the aspects that freight respondents include in their VTTF (and VTTRF)

	Time changes related to the cargo	Time changes related to the vehicles and staff
Carrier	Not included	Included
Own account shipper	Included	Included
Shipper that contract out	Included	Not included

Carriers are in the best position to give the component of the VTTF (and VTTRF) that is related to the costs of providing transport services. If the transport time would decrease, vehicles and staff would be released for other transports, so there would be vehicle and labour cost savings.

Shippers that contract out are most interested in other aspects, as expressed by the VTTF (and VTTRF) that is related to the goods themselves. This includes the interest costs on the capital invested in the goods during the time that the transport takes (only important for high-value goods), the reduction in the value of perishable goods during transit, but also the possibility that the production process is disrupted by missing inputs or that customers cannot be supplied due to lack of stock. The latter two arguments are also (possibly even more so) important for the VTTRF.

Shippers with own account transport can give information on both the values that are related to the costs of providing transport services and the values that are related to the goods themselves. If both these components of the VTTF (VTTRF) are properly distinguished, the carrier VTTF (VTTRF) and shipper (contract out) VTTF (VTTRF) can be added to obtain the overall VTTF (VTTRF) for use in societal cost-benefit analysis.

Of course, there may be exceptions to the general pattern depicted in Table 61, but in the questionnaires the researchers steered the shippers that contract out only to answer on the components they generally know most about (bottom-left), and likewise for carriers (top-right). This was done by giving very explicit instructions and explanations to get clearly defined component values from each type of agent. In other words, the researchers:

- Explained to all respondents that the changes in time, costs and reliability are generic: these apply to all carriers using the same infrastructure, and are not competitive advantages for their specific firm.

- Explained to carriers that a shorter transport time might be used for other transports: the staff and vehicles/vessels can be released for other productive activities. A higher reliability means that the carriers can be more certain about such re-planning/re-scheduling. The researchers also explained that the carriers do not have to consider what would happen to the goods (deterioration, disruption of production process, running out of stock, etc.) if they were late.
- Explained to the shippers that contract out that they only need to take into account what would happen to the goods (deterioration, disruption of production process, running out of stock, etc.) if the transport time or its reliability would change.
- Explained to shippers with own account transport that they have to take all of this (= cargo and staff/vehicle) into account.

The VTTF from the SP survey (transport services component plus cargo component) are directly used for road transport. For non-road transport, the SP survey was used to determine the trade-off ratios between transport time and cost (and reliability). Together with the factor costs, these ratios can be converted into the VTTF. These values are used for the impact in year 1, but for year 10 and later, the full factor costs are used as the VTTF. For years between year 1 and 10, a linear interpolation is used to reflect the gradual shift to the situation with the full effects of time savings.

In the SP experiments to determine the VTTRF, transport time reliability was presented to the respondents in the form of five equi-probable travel times with the corresponding arrival times (all within a single choice alternative). The SP experiments were carried out among more than 800 shippers and carriers, making the data set arguably the largest ever in freight in terms of the number of interviews. In the models estimated on the SP data, unreliability was expressed as the standard deviation of transport time. This definition was chosen especially because it is relatively easy to incorporate in transport forecasting models. The study was the first to make a very explicit distinction between the cargo and the transport costs component in both the VTTF and the VTTRF and the interviews were arranged so that the shippers would provide the former and the carriers the latter. The outcomes are now used in CBA in The Netherlands.

Results from Significance et al. (2013) on the reliability ratio (RR): [28]

- overall reliability ratio for road: 0.37
- overall reliability ratio for rail: 0.18
- overall reliability for air: 0.12
- overall reliability ratio for inland waterways: 0.09 (waiting for a quay) – 0.35 (waiting for a lock or a bridge)
- overall reliability ratio for sea: 0.12 (waiting for a quay).

15.5 Results

A key result from the international literature review (see Appendix F) is that the transport service component of the VTTF will be (especially in the long run) more or less equal to the cost of producing the transport services per hour (the sum of the staff and vehicle cost per hour including overheads, but not including distance-dependent cost). It is therefore not really needed to do new SP research to get these values; one can simply use the factor costs method (preferably excluding the distance-dependent costs) to find this component. This component will hardly or not vary between commodity types, but it will vary between modes.

The cargo component of the VTTF cannot so straightforwardly be derived from the factor cost. This should be based on specific SP surveys. The 2009-2011 study in the Netherlands (Significance et al.,

[28] For passenger transport, we found reliability ratios in 2022 that were much lower than in the 2009/2011 study. One of the explanations was the confusion between the common travel time (which was presented) and the average travel time (which was used in the modelling). The same issue might have influenced the reliability ratios in freight transport for road, rail and air, though the confusion might have been (much) less due to the fact that all interviews were in-person so that more time was taken to answer the questions and that any possible confusion could have be directly resolved. This issue did not apply to the inland waterways and sea transport modes, since in those experiments the average waiting time was presented (rather than the most common one).

2013) showed that the cargo component of the VTTF is about 10% (non-container) to 20% (container) of the full transport cost. In principle, variation between commodity types (which one would expect for the cargo component) could be derived from the French, German or UK results, but we prefer that new values for the Netherlands are based on research in The Netherlands only, so no distinction between commodity types is included.

For road transport, we work out two different methods:

- Option 1, which is consistent with the approach for road transport used in Significance et al. (2013): consistency over time;
- Option 2, which is consistent with the approach recommended for the other modes: consistency between modes (at the same moment in time).

15.5.1 VTTF for road transport (option 1)

In Significance et al. (2013), the models for the non-road modes were relative models where the VTTF depended on the factor cost. In contrast, for road modes more standard models were successfully estimated, that directly yield a VTTF without inputs on factor cost. Option 1 builds on this direct approach and does not use the new factor cost (Panteia, 2023), whereas the new VTTF for the other modes will use these factor cost. Similar to KiM (2013), the road VTTFs according to option 1 do not use the growth to 100% of the relevant transport cost over a period of 10 years, as it used for non-road transport.

For road freight transport in option 1, we use the monetary values from the previous survey (for the full VTTF, including the transport services component and the cargo component) directly again, factoring these up or down on the basis of the change in the full factor costs for road transport. The price index numbers (i.e. the specific index for freight transport cost by road) were retrieved from CBS Statline. This approach is consistent with the recommendations for obtaining a VTTF for years in the past from Koopmans and de Jong (2004), which constituted an addition to the OEI standard CBA guidelines.

Table 62 - Calculation of VTTF for road transport (option 1), in € / hr (price level as indicated, including taxes)

	Value in KiM (2013) Price level 2010	Price index used 2010-2021 (2010=100)	New value (Option 1) Price level 2021
Container	64.40	117	75.3
Non-container	40.50	117	47.4
Average	42.20	117	49.4

15.5.2 VTTF for non-road transport (and option 2 for road transport)

For the other modes and for road under option 2, we use a different procedure. In the long run (minimally 10 years since the opening of new infrastructure) the full costs of providing the transport services are composed by the transport services component (i.e. the staff and vehicle time saved) and the the transport distance cost saved. In the short to medium run only a part of the staff and vehicle time costs may be saved if transport time is reduced (especially in non-road transport that is more capital-intensive and therefore less flexible than road transport).

The time benefits should be based on expected transport times and therefore will include expected delays (relative to the timetable) if these exist. The unexpected delays are covered in the reliability benefits.

Transport services component

A key feature of our recommended approach for time benefits in CBA of freight projects is the distinction between the short-medium term and the long run. In the long run (here defined as minimally 10 years after the start of the operation), time saved will translate fully into savings of transport crew and of overheads (together the ‘staff’ cost) and transport vehicle (depreciation, insurance, maintenance) costs (these are regarded as the time-dependent transport costs). So, for the long run VTTF in The Netherlands one can simply account for the full staff and vehicle cost per hour for freight transport of the modes studied.

For the staff and vehicle time benefits of a freight project after minimally 10 years, we take the full staff and vehicle transport cost (but not the distance-dependent transport cost, notably the energy costs, link-specific tolls and the rail access charges). These come from the factor costs project (Panteia, 2023). The factor costs calculations in Panteia (2023) are given for a number of specific vehicle and vessel types (e.g. small dry bulk transport ship). In KiM (2023a,b) weighting factors for these vehicle and vessel types are given, based on the most preferred available statistical data: for trip distance (road transport), tonne-km (for rail and inland waterways) and tonnes (sea). These weighting factors have been used to yield the result that can be found in column [1] of Table 63[29]. These values do not include the distance dependent costs (we assume that these costs are equal to the variable costs in Panteia (2023)) and refer to the year 2021 and are also in price level 2021 euros. The weighted average VAT factors (column [2]) are from KiM (2021a,b). In calculating the VAT factors, the average VAT factor of 18.2% is used for the staff cost share and the high VAT rate of 21% is applied to the non-staff share of total costs, following CPB (2015).

The recommendation for the long-term VTTF (column [4] in Table 63) is obtained by multiplying the transport cost and the VAT factor (columns [1] and [2]). The recommendation for the VTTF for year 1 [column [5]) is obtained by multiplying the long-term VTTF by a short-long term ratio (column [3]) taken from the Stated Preference surveys carried out around 2010 in the Netherlands (the responses of the firms in these surveys are regarded as inherently short-term in nature).

For the first year we thus recommend that the ratio between short and long run is taken from Significance et al. (2012b) and then multiplied by the full staff and vehicle cost (as used for year 10 and later), as we did for the last column of Table 63. Rail is a typical example of a sector with high capital cost (trains, but especially tracks, platforms, stations, marshalling yards, cranes), so here we would expect that the ratio of the short term value to the long run value is smaller than for other modes, which is indeed what we find (0.32). For sea and air freight transport the capital cost are also substantial, but smaller since these concern point infrastructure (nodes), not also line infrastructure. Hence the possibilities of changing operations in the short run are larger than for rail. Here we find indeed higher ratios of short versus long (0.56 and 0.62). For inland waterways, we find a large difference in the short to long run ratios between waiting for a quay and waiting for a lock/bridge (see Table 63), but the average of these two ratios is close to the ratio for sea transport.

For road transport, Significance et al. (2013) did not contain a model that produces the short-term VTT as the share of the factor costs[30]. Given the nature of road transport relative to the other modes (highly competitive and flexible sector with a much lower capital intensity than for the other models), the ratios for road from 2003/2004 and the general correspondence between the long run values for option 2 and the values from option 1 (which were applied for the first year already in KiM, 2013), we use 100% of the long run value for the factor costs component already for year 1.

For the years in between year 1 and 10, we recommend linear interpolation to get the transport service component of the VTTF.

[29] The shares used for container versus non-container from KiM (2023a,b) are: rail: 43%/57%; inland waterways: 16%/84%; sea: 23%/77% and road: 11%/89%.

[30] Relative models for road transport were estimated in the national freight VTT study in 2003/2004. Here we obtained for road transport ratios for the VTT to the factor costs between 0.79 and 0.98, depending on the commodity type (de Jong et al., 2004).

Table 63 - Calculation of new long-term and year 1 VTTF per hour for the transport services component for non-road modes (including VAT)

Mode	Transport cost from new factor cost report (price level 2021) [1]	Weighted average VAT factor (KiM, 2021) [2]	Ratio short-long run (Significance, 2012b) [3]	Recom-mended new long-term value (price level 2021) [4]	Recom-mended new value for year 1 (price level 2021) [5]
Rail					
Container	645	1.21	0.32	780	250
Non-container	846	1.21	0.32	1024	328
Average	760	1.21	0.32	920	294
Air					
Average	5888	1.21	0.62	7124	4417
Inland waterways					
Container-quay	108	1.20	0.13[31]	130	17
Container – lock/bridge	108	1.20	0.96[31]	130	124
Non-container - quay	122	1.20	0.13[31]	146	19
Non-container – lock/bridge	122	1.20	0.96[31]	146	141
Average - quay	119	1.20	0.13[31]	143	19
Average – lock/bridge	119	1.20	0.96[31]	143	137
Sea					
Container	771	1.21	0.56	933	522
Non-container	728	1.21	0.56	881	493
Average	738	1.21	0.56	893	500
Road option 2					
Container	41.5	1.20	1	49.8	49.8
Non-container	44.9	1.20	1	53.9	53.9
Average	44.5	1.20	1	53.4	53.4

Cargo component

For the cargo component in the VTTF for the non-road modes, we use the result from the previous Dutch national study (Significance et al., 2013) that these costs are 20% of the transport costs for container transport and 10% for non-container. The average for each mode depends on the relative importance of container and non-container shipments. These costs are calculated in Table 64. The cargo component does not grow to 100% over 10 years, but by its very nature applies fully from year 1 onwards.

[31] Note that this ratio is much lower for waiting at a quay than for waiting at a lock or a bridge. A possible reason for this is that waiting at a quay can be planned better whereas waiting for a lock or a bridge is more unpredictable.

Table 64 - Calculation of the VTTF for the transport services component (including VAT) and the overall VTTF, in € / hr (price level 2021, including taxes)

Mode	Transport cost component (VAT included)	Cargo component fraction	Cargo component (short=long term)	Overall VTTF
Rail				
Container	780	20%	156	936
Non-container	1024	10%	102	1126
Average	920	14.3%	132	1052
Air				
Average	7124	10%	712	7836
Inland waterways				
Container- quay	130	20%	26	156
Container – lock/bridge	130	20%	26	156
Non-container - quay	146	10%	15	161
Non-container – lock/bridge	146	10%	15	161
Average - quay	143	11.6%	17	160
Average – lock/bridge	143	11.6%	17	160
Sea				
Container	933	20%	187	1120
Non-container	881	10%	88	969
Average	893	12.3%	110	1003
Road option 2				
Container	49.8	20%	10.0	59.8
Non-container	53.9	10%	5.4	59.3
Average	53.4	11.1%	5.9	59.3

15.6 Final values for the VTTFR

For the VTTRF we do not explicitly distinguish a transport cost and a cargo component because there is no empirical literature that gives these two components. The evidence that we have (especially from the Netherlands) is that the total reliability benefits below can be taken to be the same as the cargo component of reliability, with zero value for the transport services component of reliability.

Similarly to what was said for the cargo component of the VTTF, for the VTTRF the preferred method is to carry out a new specific SP study, which could be combined with the VTTF. Since this not be possible now, updated default values are provided below.

As in the Dutch CBA, the reliability for all modes is defined as the standard deviation of transport time. The importance of the standard deviation relative to transport time itself is given by the reliability ratio. The reliability ratio refers to intrinsic remaining reliability and not to savings in expected transport time gained from improving reliability (the latter are evaluated using the VTTF).

In the discussion on the VTTRF above, we found that the reliability ratios (RRs) from Significance et al. (2013) for road transport and rail transport are close to the central tendency values from the international literature of 0.4 and 0.2 respectively. For the other modes there is not enough material in the literature for a comparison. In the absence of a new Dutch VTTRF study, we recommend re-using the RRs by mode from Significance et al. (2013). In Table 65 below, these RR values are presented and used to calculate the VTTRF from the new long-term VTTF (for road option 1 this comes from directly from Table 62; for the non-road modes and road option 2 this is the sum of the first and third column in Table 64). Given that the VTTRF consists of a cargo component only, we do not distinguish between a short-term VTTRF and a long-term VTTRF, but apply the full VTTRF in year 1 already (as we did for the cargo component in the VTTF).

Table 65 - Recommended unit values for the reliability ratio and VTTRF, in € / hr (price level 2021, including taxes)

	Reliability ratio	Long-term VTTF	VTTRF for standard deviation per hour (short=long term)
Road option 1	0.37	49.4	18.3
Road option 2	0.37	59.3	21.9
Rail	0.18	1052	189
Air	0.12	7836	940
Inland waterways: quay	0.35	160	56.0
Inland waterways: bridge/lock	0.09	160	14.4
Sea	0.12	1003	120

For road transport, the option 1 values are consistent with the approach and results of Significance et al. (2013), expressing consistency over time within road transport. Option 2 for road transport yields values that are consistent with those for the other modes (consistency between modes). In our view, the latter consistency is more important, since in project assessment, projects for various modes are compared in the same framework. We therefore recommend using the option 2 values for road transport and will only present these in the conclusions section below.

15.7 Discussion

15.7.1 Results in Euro-2021

The freight time benefits of a transport project consist of the staff and vehicle time savings (together: the transport services component) and the cargo component. The former is calculated by taking all savings in transport costs except those for energy, tolls and rail access. For the first years after the start of a project we take a part of the full staff and vehicle time savings, from year 10 on we take the full staff and vehicle time benefits. For the cargo component we take 20% (containers) or 10% (non-container) of the long-run transport services component.

Reliability is measured as the standard deviation of time. The benefits are calculated with the help of reliability ratios that give the value of the standard deviation relative to the value of time (both per hour).

The distance costs need to be included in the CBA separately.

Table 66 summarises the main recommendations for the VTTF and VTTRF for the Netherlands in 2021 euros. This table no longer contains two options for road transport. Only our preferred option for road transport (option 2 that is more consistent with the approach used for the other modes than option 1) is presented here.

Table 66 - Recommended VTTF and VTTRF, in € / hr (price level 2021, including taxes)

	VTTF					VTTRF
	Transport services component		Cargo component	Total		Total (= cargo component)
	Long term	Year 1	Long term = Year 1	Long term	Year 1	Long term = Year 1
Road option 1						
Container	49.8	49.8	10.0	59.8		
Non-container	53.9	53.9	5.4	59.3		
Average	53.4	53.4	5.9	59.3		21.9
Rail						
Container	780	250	156	936	406	
Non-container	1024	328	102	1126	430	
Average	920	294	132	1052	426	189
Air						
Average	7124	4417	712	7836	5129	940
Inland waterways						
Container- quay	130	17	26	156	43	
Container –lock/bridge	130	124	26	156	150	
Non-container - quay	146	19	15	161	34	
Non-container – lock/bridge	146	141	15	161	156	
Average - quay	143	19	17	160	36	56.0
Average – lock/bridge	143	137	17	160	154	14.4
Sea						
Container	933	522	187	1120	709	
Non-container	881	493	88	969	581	
Average	893	500	110	1003	610	120

15.7.2 Comparison with the results of the previous study

The new results for the VTT and VTTR in Table 66 are substantially lower than those from Significance et al. (2013). There are two important reasons for this divergence:

- The factor cost for most of the modes have gone down (2021 compared to 2009), in real terms and in nominal terms;
- Unlike in Significance et al. (2013), in the current study we decided not to include the distance-dependent costs in the factor cost that are used for the calculation of the freight VTTs (and VTTRs).

The argument for the latter is that a change in transport time that is caused by a transport project should be related to the time-dependent transport costs only. Since 2013, in international projects such as for Jaspers (cooperation body of EIB, EBRD and EC; JASPERS, 2017), UK DfT (Arup et al., 2020) and a presentation for the new French CBA committee, we have argued ourselves that the transport services cost component of the VTT should use the time-dependent costs (these are mainly staff and vehicle costs) and not the distance-dependent costs (especially fuel). The principals agreed with these recommendations. We are now also applying this internationally agreed approach to the Dutch situation.

Our recommendation is also that if a project changes the distance-dependent transport costs (it may reduce not only congestion but also distance), this will be taken into account separately in the CBA as a transport cost change. The distance-dependent costs do not change one-to-one with the change in the travel time gains. One should avoid double counting of effects, but also avoid omitting relevant effects. EIB and UK (TAG) have been using this approach with regards to fuel costs and related cost for years and this is part of their appraisal guidance.

The decision to exclude the distance-dependent or variable transport costs had a profound impact on the resulting VTTs. In Table 67 we compare the results of the selected approach (without variable costs in the VTT) against the approach that would use the full transport costs (as in Significance et al., 2013). For sea transport the new approach reduces the values by 50% and for air transport even more. For the other modes the difference are smaller (because variable costs are relatively less important), but not small.

Table 67 - Recommended VTTF and VTTF when variable (distance-dependent) cost would have been included, in € / hr (price level 2022, including taxes)

	Without variable costs in factor costs	With variable costs in factor costs
Road transport		
Container	59.8	89.3
Non-container	59.3	88.5
Average	59.3	88.5
Rail transport		
Container	936	1265
Non-container	1126	1521
Average	1052	1421
Air transport		
Average	7836	16672
Inland waterway transport		
Container- quay	156	203
Container –lock/bridge	156	203
Non-container - quay	161	209
Non-container – lock/bridge	161	209
Average - quay	160	208
Average – lock/bridge	160	208
Sea transport		
Container	1120	2240
Non-container	969	1938
Average	1003	2006

15.7.3 Conversion to Euro-2022

The results for passenger transport are in euros of 2022. The above results for freight transport are in euros of 2021, because the factor costs used refer to 2021 and are in euros of 2021. It is important to have results for passenger and freight transport on the same basis. Therefore the 2021 outcomes for freight were converted into euros of 2022. This conversion consists of two elements. First there is the general price index (of consumption, the so-called 'CPI'), which represents overall inflation. In the second place we also add 50% of the real wage rate change for road transport and 25% of the real wage rate change for the other modes, following the guidelines for CBA in The Netherlands on changes in the real freight VTT over time (Ministerie van Verkeer en Waterstaat and Centraal Planbureau, 2004).[32] The increase in the general price level from 2021 to 2022 was 10.0%. The real wage rate change in this period was negative (-7.06%). The resulting multiplication factors that we used were 1.0635 for road transport and 1.0812 for the other modes.

[32] In Significance (2013) we also had to convert factor costs in prices of 2009 into 2010 prices. In 2013 we also used the CPI for this, but restricted the conversion to the first component.

Table 68 - Recommended VTTF and VTTRF, in € / hr (price level 2022, including taxes)

	VTTF					VTTRF
	Transport services component		Cargo component	Total		Total (= cargo component)
	Long term	Year 1	Long term = Year 1	Long term	Year 1	Long term = Year 1
Road						
Container	53.0	53.0	10.6	63.6		
Non-container	57.3	57.3	5.7	63.1		
Average	56.8	56.8	6.3	63.1		23.3
Rail						
Container	843	270	169	1012	439	
Non-container	1107	355	110	1217	465	
Average	995	318	143	1137	461	204
Air						
Average	7702	4776	770	8472	5545	1016
Inland waterways						
Container- quay	141	18	28	169	46	
Container – lock/bridge	141	134	28	169	162	
Non-container - quay	158	21	16	174	37	
Non-container – lock/bridge	158	152	16	174	169	
Average - quay	155	21	18	173	39	60.5
Average – lock/bridge	155	148	18	173	167	15.6
Sea						
Container	1009	564	202	1211	767	
Non-container	953	533	95	1048	628	
Average	966	541	119	1084	660	130

16. Concluding remarks

In this section we will reflect on a number of elements of this study: the considerations for adopting the RU-LIN theoretical framework and new insights gained from the study. The new insights can lead to important avenues for VTT elicitation studies to explore in the future. The results that form the basis of this discussion in this chapter can be reviewed in the summary, or in Chapters 10 through 15 of the report.

Choice model framework

We used a utility function based on the linear Random Utility framework (RU-LIN), rather than the logarithmic Random Valuation framework (RV-LOG) that has been adopted in other recent national VTT studies. The RV-LOG framework has gained popularity in recent studies as it generally fits the data better than its RU-LIN counterpart; a notion also observed in our analysis. However, after careful considerations on the pros and cons of both frameworks, we concluded that the RU-LIN approach is more robust for this study since (1) it could also be used for 3-and-more attributes experiments (whereas RV-LOG cannot), (2) it is theoretically better-founded in academic literature and (3) there is no contamination between the mean VTT and the heterogeneity of the VTT within the population. The last point describes a worry posited in the 2014 UK VTT study (ARUP et al., 2015) that the error term in RV-LOG approaches likely captures not just noise, but also heterogeneity in the VTT. Also, based on our ongoing research, there is evidence that the VTT in RU-LIN vs RV-LOG has a slightly different mathematical interpretation. All in all, there remains some uncertainty regarding the interpretation of the VTT derived from a RV-LOG approach, so that as this point we are not comfortable to step away from the RU-LIN framework. We identify an important path for future research in this area.

New insights

During this study we have gained several new insights that are beneficial to future value of travel time elicitation studies.

First, to recover the full range of the VTT distribution within the population, we have improved upon existing design techniques for 2-attribute time/cost SP experiments. We combined the ideas of a D-efficient design adopted in the UK 2014 VTT study (Batley et al. 2017), with the ideas of a design that probes a wide range of BVTT values as was used in several Scandinavian studies such as Denmark 2004 (Fosgerau et al. 2007), Sweden 2008 (Börjesson & Eliasson 2014), Norway 2009 (Ramjerdi et al. 2010) and Norway 2019 (Halse et al. 2022). For our design, we first created a candidate set of choice tasks that covered all possible BVTT combinations. From this candidate set, the final set of choice tasks was selected under the condition that each respondent received four choice tasks covering the more extreme and pre-defined BVTT ranges, and four choice tasks optimised for D-efficiency with more modest BVTTs. In the final data set only 1% of the respondents always chose the most expensive alternative, which is lower than any other recent national VTT study in Europe. This has made it much easier to identify the entire width of the VTT distribution.

Secondly, no significant VTT difference was found between respondents recruited via intercept and via an internet panel. The only exception was found for car drivers. Car respondents who were recruited at parking locations or fuel stations had on average a 16% (Mixed Logit model) to 23% (MNL model) higher VTT than car drivers that were recruited via the internet panel. This contrasts with the findings from the previous Dutch VTT study where it was found that members of a general internet panel travelling for commute and business purposes had a 13%-20% lower VTT, irrespective of their travel mode. A more detailed analysis showed that the highest VTT was found for respondents recruited at parking garages in Amsterdam (51% higher VTT compared to the internet panel). Uncoincidentally, this also was the most expensive location (at parking fees of € 6.20 per hour). This might be a type of self-selection effect: only people with a high VTT use expensive parking garages. This finding is evidence that – under the conditions of careful recruitment and rewards for respondents – panel and intercept recruitment render similar results.

Thirdly, a non-parametric analysis of the 2-attribute time/cost choice data revealed that the VTT distribution within the sample is well-described by a lognormal distribution. The same analysis was repeated on time/reliability choice data from which it was concluded that also the RR distribution within the sample can be described well by a lognormal distribution. We conclude that the use of non-parametric techniques to identify the shape of the VTT distribution is best practice in developing parametric Mixed Logit models.

Furthermore, if a joint Mixed Logit model is estimated on joint data from a 2-attribute time/cost experiment and from a 3-attribute time/cost/reliability experiment, and if separate VTT values are estimated for both data sets, the VTT estimated on the 3-attribute data is about 50% higher than the VTT estimated the 2-attribute data. This result is consistent with results found in other studies such as the 2014-UK study (ARUP et al. 2015, Hess et al. 2020) and point towards paths for future research.

Additionally, in the final Mixed Logit model estimated on both the 2-attribute time/cost choice data and the 3-attribute time/cost/reliability data, both the VTT and the VTTR were considered random variables with a lognormal distribution. However, the VTT and VTTR are not independent: we have found that they are correlated with a correlation factor between 0.17 and 0.63 (depending on mode). We have not seen publication of correlation factors in earlier VTT studies.

Finally, for commute and other purposes, the mix of travellers and trips that they make has changed slightly between 2010 and 2022. This will have resulted in a modest increase of the VTT of about 3-4% on average. However, for business trips this is different. The change in the mix of travellers and trips that they make, is likely to have reduced the VTT between 2022 and 2010 by 15-26%. So, business trips in 2010 are clearly different from business trips in 2022. A likely explanation are the increased possibilities for remote work and online meetings. Especially highly educated, high income business travellers are likely to substitute in-person meetings for remote work alternatives, which will reduce the average VTT for business. Another explanation might be that business trips in 2022 are on average shorter than in 2010. Both effects are partly – yet not fully – related to the Covid-19 pandemic. According to our estimates, roughly half of the total impact over the period 2010-2022 can be attributed to these effects. In other words, there already was a changing pattern between 2010 and 2019 in business trips, which has been accelerated since then.

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Appendices

Appendix A: SP designs

This appendix describes the details of the designs of the SP experiments. In Section A.1 the basic characteristics of each experiment are described in a systematic way. For most experiments, this information covers all relevant details. However, for the SP1A/B/C experiments, a more innovative and complex design has been used. This is described in Section A.2. In the section thereafter, this new design is compared to other design strategies that have been used in earlier VTT studies in northwest Europe.

A.1 Basic characteristics per experiment

A.1.1 SP1A

Objective: determine the value of travel time

Type of experiment: route choice experiment

Number of design blocks: 9

Number of choice situations: 8 per design block (i.e. per respondent)

Number of alternatives: 2

Number of attributes: 2

- Travel time 14 levels (for details, see Section A.2)
- Travel cost 15 levels (for details, see Section A.2)

Underlying design:

- D-efficient from candidate set under BVTT restrictions, generated by Ngene. Full details in Section A.2.
- 10% of the non-business respondents got a set of 8 choice questions based on the same underlying design that was used in the 2009/2011 study. The remaining 90% got 8 choice questions based on a new underlying design in which 4 choice pairs were "quadrant-type" and 4 choice pairs were non-quadrant-type.[33]

Randomisation:

- For each respondent, the design block number (out of 9) was determined by a random draw.
- Order of the choice questions was randomised for each respondent.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents.
- Order of the attributes was randomised between respondents (with 2 possible orders).

A.1.2 SP1B

Objective: determine the value of travel time for the travel modes cycling and walking

Type of experiment: mode choice experiment

[33] Quadrant-type questions always have BaseTime and BaseCost in one of the alternatives (not necessarily in the same alternative). In other words: these are pure WTP, WTA, EG or EL-type questions.

Number of design blocks: 4

Number of choice situations: 8 per design block (i.e. per respondent)

Number of alternatives: 2

- Walking or Cycling (depending on mode of current trip)
- Rental E-bike or car (depending on preferred alternative mode if current mode is not available)

Number of attributes: 2

- Travel time 5 levels (for details, see Section A.2)
- Travel cost 7 levels (for details, see Section A.2)

Underlying design:

- D-efficient from candidate set under BVTT restrictions, generated by Ngene. Full details in Section A.2.

Randomisation:

- For each respondent, the design block number (out of 4) was determined by a random draw.
- Order of the choice questions was randomised for each respondent.
- Order of the left/right alternatives was randomised between respondents, but not within respondents. This implies that a respondent always saw the same modes on the left- and right-hand alternatives.
- Order of the attributes was randomised between respondents (with 2 possible orders).

A.1.3 SP1C

Objective: determine the value of waiting time for passing a lock or a bridge

Type of experiment: route choice experiment

Number of design blocks: 4

Number of choice situations: 8 per design block (i.e. per respondent)

Number of alternatives: 2

Number of attributes: 2

- Wait time before bridge / lock 7 levels
- Cost per passage 7 levels

Level	Wait time before bridge / lock (in min.)	Cost per passage (in €)
1	0	0.00
2	5	0.25
3	10	0.50
4	15	1.00
5	30	2.00
6	45	4.00
7	60	8.00

Underlying design:

- D-efficient from candidate set under BVTT restrictions, generated by Ngene. Full details in Section A.2.
- 10% of respondents were presented by a choice set based on the 2009/2011 design.

Randomisation:

- For each respondent, the design block number (out of 4) was determined by a random draw.
- Order of the choice questions was randomised for each respondent.
- Order of the left/right alternatives was randomised within and between respondents.
- Order of the attributes was randomised between respondents (with 2 possible orders).

A.1.4 SP2A

Objective: determine the value of travel time reliability.

Type of experiment: route choice experiment

Number of design blocks: 8

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

Number of alternatives: 2

Number of attributes: 3

- Travel time 7 levels
- Travel time reliability 5 levels
- Travel cost 7 levels

Level	Travel cost change	Travel time change	Travel time reliability Stdev
1	-2.00	-12	4
2	-1.00	-4	8
3	-0.40	-1	12
4	0.00	0	16
5	+1.20	1	20
6	+2.50	4	
7	+5.00	12	
	x BaseTimeFac xBVTTfac	x BaseTimeFac	x BaseTimeFac

For explanation on BaseTimeFac, BVTTfac, see Section A.2

The five possible travel times that are presented are obtained as follows. First, for each choice alternative a random draw determines the skewness of the travel time distribution (3 levels: normal, lognormal and skewed). Next, the five times are calculated by multiplying the standard deviation (from the design table) with the following factors, and rounded to the nearest minute.

Possible time	Normal	Lognormal	Skewed
1	-1.45833	-1.33333	-1.16667
2	-0.60833	-0.62500	-0.62500
3	0.00000	-0.16667	-0.37500
4	0.60833	0.54167	0.45833
5	1.45833	1.58333	1.70833

Underlying design:

- D-efficient from candidate set under restrictions, generated by Ngene. Restrictions were:
  - No dominant questions;
  - Four questions need to have the same cost level on both alternatives;
  - Of these four questions with same cost level on both sides, the BRR (i.e. boundary reliability ratio, which is equivalent to BVTT) should be well distributed over the full range between 0 and 6.
- 10% of the non-business respondents got a set of 8 choice questions based on the same underlying design that was used in the 2009/2011 study. The remaining 90% got 8 choice questions based on a new underlying design in which 4 choice pairs had a cost difference between the two alternatives and 4 choice pairs had equal costs for both alternatives, making them effectively a two-attribute sub-experiment within a three attribute experiment. The four boundary reliability ratios (BRR, i.e. the equivalent of a boundary value of time in the SP1A experiment) for each respondent were equally distributed over the range of possible BRRs.

Randomisation:

- For each respondent, the design block number (out of 8) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was randomised between respondents (with 4 possible orders).

A.1.5 SP2B

Objective: determine the travel time multipliers for walking and cycling path comfort levels

Type of experiment: route choice experiment

Number of design blocks: 8

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

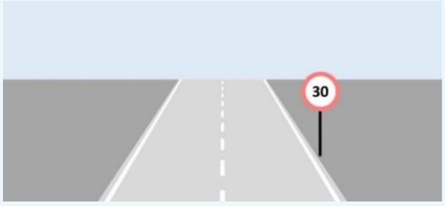
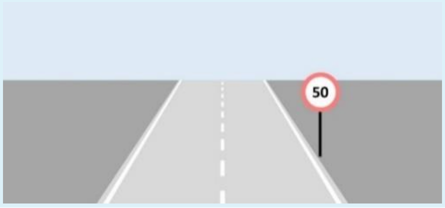
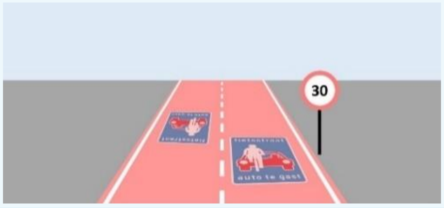
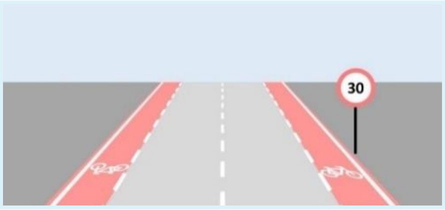
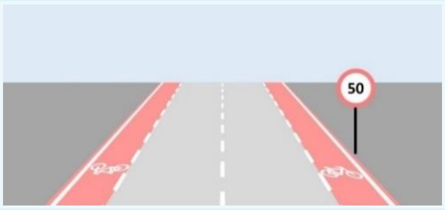
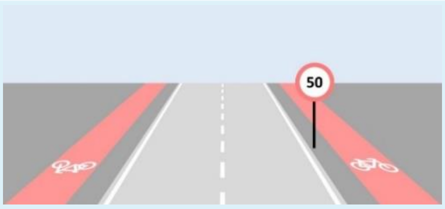
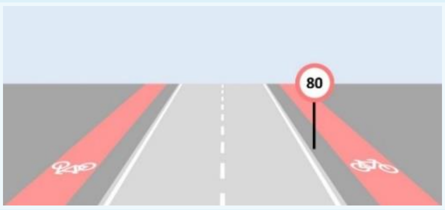
Number of alternatives: 2

Number of attributes: 5

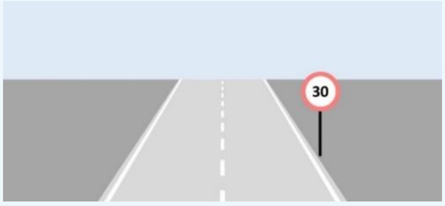
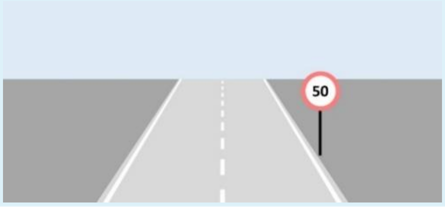
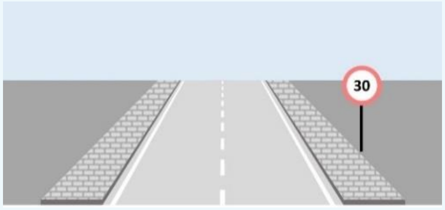
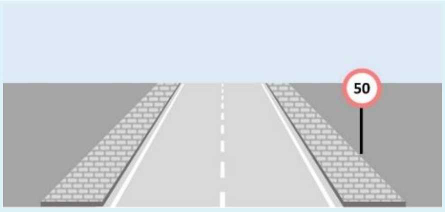
- Travel time: 8 levels

Level	Factor on travel time of current trip
1	67%
2	83%
3	92%
4	100%
5	110%
6	120%
7	140%
8	160%

- (Cycling only:) cycling path configuration: 8 levels

Level	Cycling path configuration *Dutch* / English	
1	*Gedeelde weg met auto's (30 km/u)* Car road – bikes allowed (30 km/h)	
2	*Gedeelde weg met auto's (50 km/u)* Car road – bikes allowed (50 km/h)	
3	*Fietsstraat (auto's toegestaan, voorrang voor fietsers, 30 km/u)* Bike street – cars allowed, bikes have priority (30 km/h)	
4	*Fietsstrook met onderbroken streep (30 km/u)* Bike lane in the road (30 km/h)	
5	*Fietsstrook met onderbroken streep (50 km/u)* Bike lane in the road (50 km/h)	
6	*Vrijliggend fietspad langs een weg (50 km/u)* Bike lane next to the road (50 km/h)	
7	*Vrijliggend fietspad langs een weg (80 km/u)* Bike lane next to the road (80 km/h)	
8	*Vrijliggend fietspad (zonder andere weg in de buurt)* Bike path (no other road around)	

- (Walking only:) walking path configuration: 8 levels

Level	Walking path configuration *Dutch* / English	
1	*Lopen op weg waar ook auto's en fietsers rijden, geen apart voetpad (30 km/u)* Walking on road with cars and bikes, no pedestrian path (30 km/u)	
2	*Lopen op weg waar ook auto's en fietsers rijden, geen apart voetpad (50 km/u)* Walking on road with cars and bikes (50 km/u) , no pedestrian path	
3	*Stoep direct langs weg waar fietsers en auto's rijden (30 km/u)* Sidewalk directly next to road with cars and bikes (30 km/u)	
4	*Stoep direct langs weg waar fietsers en auto's rijden (50 km/u)* Sidewalk directly next to road with cars and bikes (50 km/u)	
5	*Stoep op 2 meter langs weg waar fietsers en auto's rijden (30 km/u)* Sidewalk at 2 metres from road with cars and bikes (30 km/u)	
6	*Stoep op 2 meter langs weg waar fietsers en auto's rijden (50 km/u)* Sidewalk at 2 metres from road with cars and bikes (50 km/u)	
7	*Vrijliggend fiets/voetpad (geen autoverkeer)* Shared bike/pedestrian path (no car traffic)	
8	*Vrijliggend voetpad (geen autoverkeer)* Pedestrian path (no car traffic)	

- (Cycling only:) Pavement: 4 levels

Level	Pavement Dutch	English
1	*Klinkers*	Paving stones
2	*Stoeptegels*	Sidewalk tiles
3	*Betonplaten*	Concrete slabs
4	*Asfalt*	Asphalt

- (Walking only:) Walking path width: 4 levels
  - This attribute is not presented is walking path configuration is level 1 or 2 (walking path on the road with cars and bikes)

Level	Walking path width Dutch	English
1	*Smal pad (minder dan 1 m breed) met obstakels (geparkeerde fietsen, bloembakken etc.)*	Narrow path (less than 1 m) with obstacles (parked bikes, flower beds etc.)
2	*Smal pad (minder dan 1 m breed) zonder obstakels*	Narrow path (less than 1m) without obstacles
3	*Normaal pad (1 tot 2 m breed)*	Normal path (1 – 2m wide)
4	*Breed pad (meer dan 2 m breed, boulevard-achtig)*	Wide path (more than 2m wide, boulevard-like)

- Amount of bypassing cars: 4 levels
  - (Cycling:) this attribute is not presented if cycling path configuration is level 8 (bike path without other road around)
  - (Walking) this attribute is not presented if walking path configuration is level 7 or 8 (pedestrian path without car traffic)

Level	Amount of bypassing cars Dutch	English
1	*Zeer weinig*	Very few
2	*Weinig*	Few
3	*Veel*	Many
4	*Zeer veel*	Very many

- Route: 4 levels

Level	Route Dutch	English
1	*Zeer mooi*	Very beautiful
2	*Mooi*	Beautiful
3	*Niet mooi*	Not beautiful
4	*Helemaal niet mooi*	Absolutely not beautiful

Underlying design:

- D-efficient from candidate set, generated by Ngene.

Randomisation:

- For each respondent, the design block number (out of 8) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.

- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was randomised between respondents (with 5 possible orders).

A.1.6 SP2C

Objective: determine the value of waiting time reliability for passing a lock or a bridge

Type of experiment: route choice experiment

Number of design blocks: 4

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

Number of alternatives: 2

Number of attributes: 3

- Wait time before bridge / lock 5 levels
- Waiting time reliability 5 levels
- Cost per passage 7 levels

Level	Cost per passage	Wait time	Waiting time reliability
1	0.00	5	1
2	0.25	10	2
3	0.50	15	4
4	1.00	30	7
5	2.00	60	10
6	4.00		
7	8.00		

The five possible travel times that are presented to the respondents are obtained as follows. First, for each choice alternative a random draw determines the skewness of the travel time distribution (3 levels: normal, lognormal and skewed). Next, the five possible travel times are calculated by multiplying the standard deviation (as determined by the design table) with the following factors:

Possible time	Normal	Lognormal	Skewed
1	-1.45833	-1.33333	-1.16667
2	-0.60833	-0.62500	-0.62500
3	0.00000	-0.16667	-0.37500
4	0.60833	0.54167	0.45833
5	1.45833	1.58333	1.70833

Underlying design:

- D-efficient from candidate set under restrictions, generated by Ngene. Restrictions were:
  - No dominant questions;
  - Four questions need to have the same cost level on both alternatives;
  - Of these four questions with same cost level on both sides, the BRR (i.e. boundary reliability ratio, which is equivalent to BVTT) should be well distributed over the full range between 0 and 6.

- 10% of respondents were presented by a choice set based on the "old" design, i.e. the design used in the 2009/2011 survey.

Randomisation:

- For each respondent, the design block number (out of 4) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was randomised between respondents (with 3 possible orders).

A.1.7 SP3A

Objective: determine travel time multipliers for the components of a public transport trip

Type of experiment: route choice experiment

Number of design blocks: 8

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

Number of alternatives: 2

Number of attributes: 5

- in-vehicle travel time: 7 levels

Current in-vehicle travel time (with a minimum of 4 minutes) + Δ, with Δ:

Current in-vehicle travel time	4 – 14 min.	15-29 min.	30-59 min.	60-89 min.	90+ min.
Level	Δ (in min.)	Δ (in min.)	Δ (in min.)	Δ (in min.)	Δ (in min.)
1	-3	-5	-10	-15	-20
2	-2	-2	-5	-10	-10
3	-1	-1	-2	-5	-5
4	0	0	0	0	0
5	1	1	2	5	5
6	2	2	5	10	10
7	3	5	10	15	20

- access/egress travel time: 5 levels

Sum of access and egress time of the current trip (with a minimum of 3 minutes) + Δ, with Δ:

Sum of the access and egress time of the current trip	3 – 14 min.	15-29 min.	30-89 min.	90+ min.
Level	Δ (in min.)	Δ (in min.)	Δ (in min.)	Δ (in min.)
1	-2	-5	-10	-20
2	-1	-2	-5	-10
3	0	0	0	0
4	1	2	5	10
5	2	5	10	20

- total wait and transfer time: 5 levels

Sum of wait and transfer time of the current trip (with a minimum of 4 minutes) + Δ, with Δ:

Sum of the wait and transfer time of the current trip Level	3 - 14 min. Δ (in min.)	15-29 min. Δ (in min.)	30-89 min. Δ (in min.)	90+ min. Δ (in min.)
1	-2	-5	-10	-20
2	-1	-2	-5	-10
3	0	0	0	0
4	1	2	5	10
5	2	5	10	20

- number of transfers: 3 levels

  Number of transfers of the current trip + Δ, with Δ:

Number of transfers of the current trip Level	0 Δ (in min.)	1+ Δ (in min.)
1	0	-1
2	1	0
3	2	1

- travel cost: 7 levels

  Current travel cost + Δ, with Δ:

Current in-vehicle travel time Level	4 - 14 min. Δ (in min.)	15-29 min. Δ (in min.)	30-59 min. Δ (in min.)	60-89 min. Δ (in min.)	90+ min. Δ (in min.)
1	-0.50	-1.00	-2.00	-3.00	-4.00
2	-0.25	-0.50	-1.00	-1.50	-2.00
3	-0.125	-0.25	-0.50	-0.75	-1.00
4	0	0	0	0	0
5	0.125	0.25	0.50	0.75	1.00
6	0.25	0.50	1.00	1.50	2.00
7	0.50	1.00	2.00	3.00	4.00

If purpose = business, all Δ are multiplied by a factor 2.5.

Underlying design:

- D-efficient design generated by Ngene.

Randomisation:

- For each respondent, the design block number (out of 8) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was randomised between respondents, with 5 possible orders (TIME = in-vehicle travel time; AETM = access/egress time; WTTM = wait/transfer time; NTRF = number of transfers; COST = travel cost).

Order / Attribute number	1	2	3	4	5
1	TIME	COST	NTRF	COST	AETM
2	AETM	TIME	COST	NTRF	WTTM
3	WTTM	AETM	WTTM	WTTM	TIME
4	NTRF	WTTM	AETM	TIME	COST
5	COST	NTRF	TIME	AETM	NTRF

A.1.8 SP4A

Objective: determine travel time multipliers for the level of crowding of a transport trip, and to determine the value of frequency for a public transport trip

Type of experiment: route choice experiment

Number of design blocks: 8

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

Number of alternatives: 2

Number of attributes: 5

- in-vehicle travel time: 7 levels

Current in-vehicle travel time (with a minimum of 4 minutes) + Δ, with Δ:

Current in-vehicle travel time / Level	4 - 14 min. Δ (in min.)	15-29 min. Δ (in min.)	30-59 min. Δ (in min.)	60-89 min. Δ (in min.)	90+ min. Δ (in min.)
1	-3	-5	-10	-15	-20
2	-2	-2	-5	-10	-10
3	-1	-1	-2	-5	-5
4	0	0	0	0	0
5	1	1	2	5	5
6	2	2	5	10	10
7	3	5	10	15	20

- frequency: 3 levels

Interval time between two public transport vehicles in minutes (i.e. the reciproke of the frequency of the current trip)	**Level**	
0 – 3	1	1 trein elke 5 minuten (12 per uur)
	2	1 trein elke 2 minuten (30 per uur)
	3	1 trein elke 1 minuut (60 per uur)
4 – 7	1	1 trein elke 10 minuten (6 per uur)
	2	1 trein elke 5 minuten (12 per uur)
	3	1 trein elke 2 minuten (30 per uur)
8 – 12	1	1 trein elke 15 minuten (4 per uur)
	2	1 trein elke 10 minuten (6 per uur)
	3	1 trein elke 5 minuten (12 per uur)
13 – 17	1	1 trein elke 30 minuten (2 per uur)
	2	1 trein elke 15 minuten (4 per uur)
	3	1 trein elke 10 minuten (6 per uur)
18 – 24	1	1 trein elke 30 minuten (2 per uur)
	2	1 trein elke 20 minuten (3 per uur)
	3	1 trein elke 15 minuten (4 per uur)

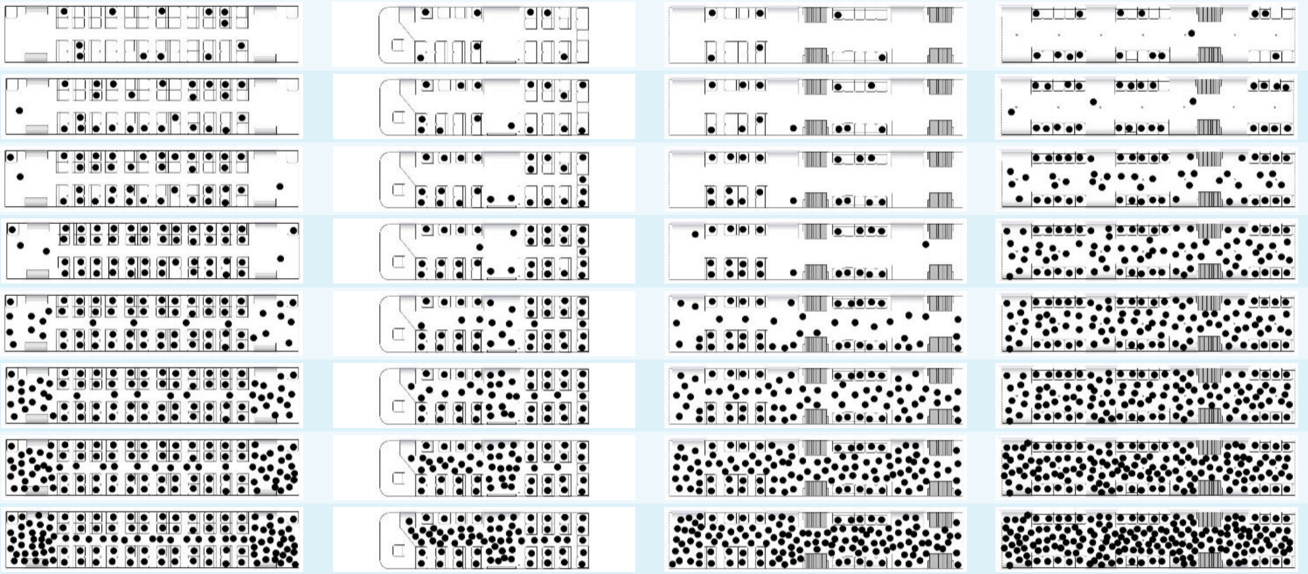
Interval time between two public transport vehicles in minutes (i.e. the reciproke of the frequency of the current trip)	**Level**	
25 – 44	1 2 3	1 trein elke 60 minuten (1 per uur) 1 trein elke 30 minuten (2 per uur) 1 trein elke 15 minuten (4 per uur)
45 – 89	1 2 3	1 trein per 2 uur 1 trein per uur 1 trein per half uur
90 or more	1 2 3	1 trein per 3 uur 1 trein per 2 uur 1 trein per uur

- level of crowding: 8 levels

  The level of crowding was presented both in text and with a figure. This figure depended on the public transport mode.

Mode	Level	Level of crowding
Train, bus, tram	1	25% van de zitplaatsen bezet, niemand staat
	2	50% van de zitplaatsen bezet, een enkeling staat
	3	75% van de zitplaatsen bezet, enkele personen staan
	4	Bijna 100% van de zitplaatsen bezet, enkele personen staan
	5	100% van de zitplaatsen bezet, er staan overal personen (1 persoon per vierkante meter)
	6	100% van de zitplaatsen bezet, er staan overal personen (2 personen per vierkante meter)
	7	100% van de zitplaatsen bezet, er staan overal personen (3 personen per vierkante meter)
	8	100% van de zitplaatsen bezet, er staan overal personen (4 personen per vierkante meter)
Metro	1	Bijna 50% van de zitplaatsen bezet, enkele personen staan
	2	Bijna 100% van de zitplaatsen bezet, enkele personen staan
	3	100% van de zitplaatsen bezet, er staan overal personen (1 persoon per vierkante meter)
	4	100% van de zitplaatsen bezet, er staan overal personen (2 personen per vierkante meter)
	5	100% van de zitplaatsen bezet, er staan overal personen (2.5 persoon per vierkante meter)
	6	100% van de zitplaatsen bezet, er staan overal personen (3 personen per vierkante meter)
	7	100% van de zitplaatsen bezet, er staan overal personen (4 personen per vierkante meter)
	8	100% van de zitplaatsen bezet, er staan overal personen (5 personen per vierkante meter)

Level	Train	Bus	Tram	Metro
1				
2				
3				
4				
5				
6				
7				
8				



- sit or stand: 2 levels

Level	Sit or stand Dutch	English
1	*U kunt zitten*	You can sit
2	*U moet staan*	You have to stand

- travel cost: 7 levels

Current travel cost + Δ, with Δ:

Current in-vehicle travel time / Level	4 - 14 min. Δ (in min.)	15-29 min. Δ (in min.)	30-59 min. Δ (in min.)	60-89 min. Δ (in min.)	90+ min. Δ (in min.)
1	-0.50	-1.00	-2.00	-3.00	-4.00
2	-0.25	-0.50	-1.00	-1.50	-2.00
3	-0.125	-0.25	-0.50	-0.75	-1.00
4	0	0	0	0	0
5	0.125	0.25	0.50	0.75	1.00
6	0.25	0.50	1.00	1.50	2.00
7	0.50	1.00	2.00	3.00	4.00

If purpose = business, all Δ are multiplied by a factor 2.5.

Underlying design:

- D-efficient design generated by Ngene.

Randomisation:

- For each respondent, the design block number (out of 8) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was randomised between respondents, with 5 possible orders (TIME = in-vehicle travel time; CRWD = level of crowding; SEST = indicator whether you were able to sit, or whether you had to stand; FREQ = frequency; COST = travel cost).

Order / Attribute num.	1	2	3	4	5
1	TIME	COST	SEST	FREQ	CRWD
2	CRWD	FREQ	COST	TIME	FREQ
3	SEST	CRWD	TIME	SEST	COST
4	FREQ	TIME	CRWD	COST	SEST
5	COST	SEST	FREQ	CRWD	TIME

A.1.9 SP5A

Objective: determine the value of travel time for the access trip to the airport of an air traveller

Type of experiment: route choice experiment

Number of design blocks: 8

Number of choice situations: 8 per design block (i.e. per respondent) + 1 dominant question

Number of alternatives: 2

Number of attributes: 6 of which 4 are independent

- Access travel time: 7 levels

Level	Factor on access travel time of current trip
1	70%
2	85%
3	95%
4	100%
5	110%
6	125%
7	160%

- Additional time at the airport: 7 levels

Level	Additional time at the airport
1	5 minutes
2	30 minutes
3	60 minutes
4	90 minutes
5	120 minutes
6	150 minutes
7	180 minutes

- Probability of missing your flight: 5 levels

Level	Additional time at the airport
1	1 in 1000
2	1 in 500
3	1 in 200
4	1 in 100
5	1 in 50.

  In the pilot survey, the level with the highest probability was 1 in 25, but alternatives with that level were never chosen so that we decided to adjust the levels afterwards;

- Access travel cost: 7 levels

Level	Factor on access travel cost of current trip
1	70%
2	85%
3	95%
4	100%
5	110%
6	125%
7	160%

The two remaining attributes are calculated as follows

- Expected arrival time at the airport = “latest possible arrival time at the airport” – “additional time at the airport”
- Departure time = “Expected arrival time at the airport” – “access travel time”

Underlying design:

- D-efficient design generated by Ngene.

Randomisation:

- For each respondent, the design block number (out of 8) was determined by a random draw.
- Order of the choice questions was randomised for each respondent, except the dominant question which was always shown as the last-but-one question.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents, except for the dominant question, which was always shown with the dominated alternative on the left-hand side.
- Order of the attributes was not randomised.

A.1.10 SP6A

Objective:	determine the value of travel time for the egress trip to the airport of an air traveller
Type of experiment:	route choice experiment
Number of design blocks:	9
Number of choice situations:	9 per design block (i.e. per respondent)
Number of alternatives:	2
Number of attributes:	2

- Travel time 14 levels (for details, see Section A.2)
- Travel cost 15 levels (for details, see Section A.2)

Underlying design:

- D-efficient from candidate set under BVTT restrictions, generated by Ngene.

Randomisation:

- For each respondent, the design block number (out of 9) was determined by a random draw.
- Order of the choice questions was randomised for each respondent.
- Order of the left/right alternatives as defined in the underlying design was randomised within and between respondents.
- Order of the attributes was randomised between respondents (with 2 possible orders).

A.2 Detailed characteristics for SP1A

A.2.1 General design strategy for the time/cost experiment

In each choice task of a time/cost experiment, the respondent is asked to make a choice between two route alternatives A and B, each described with a travel time (T) and cost (C). The ratio of the cost and time difference between these two alternatives is called the boundary value of time:

$$BVTT = -\frac{C_B - C_A}{T_B - T_A} \quad [A1]$$

If the respondent's VTT is lower than the BVTT he will generally prefer the slowest and cheapest alternative. If it is higher, he will generally prefer the quickest and most expensive alternative.

In the most recent VTT studies, the so-called Scandinavian design has been used successfully in Norway and Sweden (see Section A.4 for more information). The basic characteristic of this design is that each respondent sees a series of choice pairs with a broad BVTT range. The recent UK-study used a very different strategy: their design was optimized based on D-efficiency, without considering the BVTT range. The main advantage of this approach is efficiency, i.e. obtaining coefficients as accurately as possible for a given number of respondents.

Both approaches have advantages over the design that was used for the last VTT study in the Netherlands. Therefore, for the NL-2022 VTT we used a mix of the Scandinavian and the UK-design strategies. This means that we constructed the design such that a broad BVTT range is covered, with a sensible distribution of the BVTT within that range; and that we optimised the design for efficiency within this constraint.

Another important decision to take was whether the choices should be reference-based or not. In a reference-based design, each choice pair is in one of the WTP/WTA/EG/EL quadrants. This means that for each choice pair, the travel time of one of the alternatives is equal to the respondent's current travel time, and the travel cost of one of the alternatives (not necessarily the same) is equal to the respondent's current travel cost, as shown in the following figure:

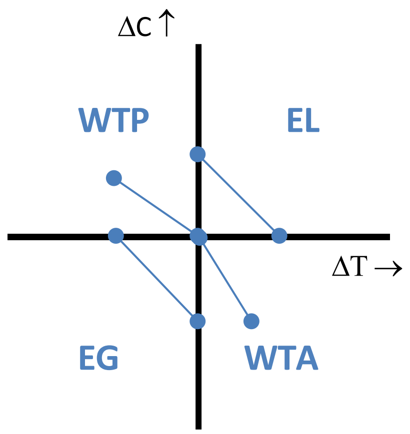


Figure A1 - Four quadrants of reference-based choice pairs

This approach has been used in most of the recent European studies (Norway 2009, 2018; Sweden 2008, Netherlands 2009/11) and has the advantage that it is simple, both for the respondents and for the analysist. However, with this design it is not completely possible to disentangle the status-quo effects and the dependence of the VTT on ΔT and ΔC. The recent UK-study was not reference-based and used a more complex model for the utility function, which turned out to be a challenge during the estimation process. So again, there are advantages and disadvantages to both approaches.

For the NL-2022 study (that was designed in 2019), we used a mix of both options. This means that four out of the eight choice pairs were reference-based and four were not. For recreational navigation (SP1C), we only used non-reference-based choice pairs. In this experiment, we presented respondents with time and cost levels irrespective of their current waiting times and passage costs, since many respondents have current levels of zero which does not work well with a reference-based design. The walking and cycling experiments couldn't be reference-based either, since the current mode-alternative (i.e. walking or cycling on a normal bike) had zero cost and the other mode-alternative (i.e. electrical rental bike or car) had a different base level for the travel time.

Table A1 - Number of SP questions per type

Mode	Design strategy		Reference-based	
	Scandinavian	Efficient	Yes	No
Car, train, local public transport	4	4	4	4
Air	4	4	4	4
Recreational navigation	4	4	-	8
Cycling / walking	4	4	-	8

A.2.2 Step 2 : Determine design segmentation within SP1

In the NL-2009/11 survey, we had different design tables for five segments:

- car/train/BTM-users that travel for a business purpose;
- car/train/BTM-users that travel for a non-business purpose (i.e. commute/other);
- air travellers travelling for a business purpose;
- air travellers travelling for a non-business purpose;
- recreational navigation

For these respondents, we expected that they have different VTTs. Within the car/train/BTM-users that travel for purpose "commute" or "other", we expected some VTT differences between these purposes. However, these differences were expected to be relatively small. Therefore, we believed we could use the same design and design tables for them. Therefore, for the NL-2022 survey, we used basically the same segmentation. In addition, we used separate design tables for walking and cycling.

A.2.3 Step 3 : Set the BVTT range

In order to set a good BVTT range, we first looked at the BVTT range the was used in previous European studies. For this, we looked at respondents travelling for a commute purpose with a base time of 60 minutes.

Table A2 - BVTT range in other surveys (respondents with purpose commute, base time = 60 min.)

	BVTT range		BVTT range (corrected for inflation)		Inflation factor
Purpose	VTT (€ / hr)	Monetary unit	VTT (€ / hr)	Monetary unit	
NL-1997	0.68 – 16.34	Euro (1997)	1.02 – 24.61	Euro (2019)	1.5062
NL-2011	0.80 – 36	Euro (2011)	0.91 – 40.73	Euro (2019)	1.1313
Sweden- 2008	0.50 – 50	Euro (2008)	0.59 – 59.33	Euro (2019)	1.1865
Norway – 2009	0.83 – 54	Euro (2009)	0.97 – 63.32	Euro (2019)	1.1725
UK-2014	0.40 – 80	Euro (2014)	0.43 – 85.34	Euro (2019)	1.0668
Norway – 2019	1 – 77	Euro (2019)	1.00 – 77.00	Euro (2019)	1.0000

A second piece of information came from the average VTT in the NL-2011 survey. Kouwenhoven & van Cranenbrugh (2019) recommended that the BVTT range should run at least from 5% to 800% of this average value. The VTTs in the following table are the results of estimation of a simple MNL-model on SP1-data from 2011.

Table A3 - BVTT range based on a 5%-800% assumption applied to NL2009/11-survey

Design segment	VTT from MNL model (€/hr)		VTT range (5% - 800%)
	Euro (2011)	Euro (2019)	Euro (2019)
Car, train, local PT / Non-business	6.36	7.20	0.36 – 57.56
Car, train, local PT / Business	13.66	15.45	0.77 – 123.63
Air / Non-business	30.57	34.58	1.73 – 276.67
Air / Business	130.08	147.16	7.36 – 1177.29
Recreational navigation	5.40	6.11	0.31 – 48.85

A third piece of information were the lower and upper bound of the VTT distribution as observed in the NL-2011 survey. However, this distribution is not observed directly. These bounds can be approximated by estimating a logit model with a random VTT parameter in which the VTT distribution should follow a log-uniform distribution. Usually, this model fits only slightly worse compared to a log-normal distribution. However, that distribution does not have an upper bound (and has a very long tail which can have a major impact on the average VTT). For this, we estimated new models on the NL-2011-data (first experiment only) for each of the segments.

Table A4 - BVTT range from a Mixed logit estimation with a log-uniform distribution

Design segment	VTT range from Mixed logit model (log-uniform distribution) (€/hr)	
	Euro (2011)	Euro (2019)
Car, train, local PT / Non-business	0.38 – 53.48	0.43 – 60.50
Car, train, local PT / Business	0.99 – 88.40	1.12 – 100.01
Air / Non-business	4.05 - 123.14	4.58 - 139.31
Air / Business	No convergence due to limited number of respondents	
Recreational navigation	1.31 - 19.08	1.48 - 21.59

When interpreting the information mentioned above, we took into account that average VTT from the MNL-model as found in Table A3 might be an underestimate of the true VTT since the maximum BVTT in the design of the NL-2011 survey as found in Table A2 was lower than the estimated upper boundary of the distribution as found in Table A4. Also, some respondents that are travelling for a business purpose, were asked to include also their employer's part of the VTT into their considerations ("WTP-method", see Appendix B). This was likely to have a positive effect on the VTT. Finally, for cycling and walking very little information was available. A Swedish study found similar VTTs for cycling as for other regular modes, however, we expected a shorter tail of the VTT distribution.

Therefore, the range of BVTT for the NL-2022 survey were set as follows:

Table A5 - Minimum BVTT range for NL-2022 SP1 experiment per segment

Design segment	BVTT range (€/hr) Euro	BVTTfac Scale factor
Car, train, local PT / Non-business	0.50 – 100	1
Car, train, local PT / Business	1.00 – 200	2
Air / Non-business	2.00 – 400	4
Air / Business	6.00 – 1200	12
Recreational navigation	0.25 – 50	0.5
Cycling, walking	0.25 – 50	0.5

We wanted to use the same idea behind the Scandinavian design, so we wanted to make sure that each respondent saw the full range of possible BVTT values. Therefore, we set conditions on the distribution of the eight BVVTs[34] that a respondent is being presented. For each respondent, we would like to have the following distribution over the BVTT intervals (depending on design segment by multiplying the BVTT range by the BVTT scale factor in Table A5):

Table A6 - Number of choices per BVTT interval

BVTT interval (€/hr)	0.01 - 1.00 x BVTTfac	1.01 - 4.00 x BVTTfac	4.01 - 40.00 x BVTTfac	40.01 - 76.00 x BVTTfac	76.01 + x BVTTfac
Number of choices per respondent	1	1	4	1	1

Note that the minimum and maximum of the BVTT range as set in Table A5 had implications for the minimum and maximum differences for the time and cost attributes, since:

$$\min(BVTT) = \frac{min(abs(C_A - C_B))}{max(abs(T_A - T_B))} \quad [A2]$$

$$\max(BVTT) = \frac{max(abs(C_A - C_B))}{min(abs(T_A - T_B))} \quad [A3]$$

A.2.4 Step 4a : Set the range of T-values for a respondent with a base time of 60 minutes

In this step we set the possible values of the time-attribute (T) for the car, train, local public transport and air design segments (the recreational navigation, cycling and walking segments are discussed in step 6. We started by setting the T-levels for a respondent with a base time (i.e. the observed time of his reference trip) of 60 minutes, which is a typical value.[35]

Table A7 - Time levels for NL-2022 SP1 experiment for respondent with BaseTime of 60 minutes

	Time levels (in min.)									Min.	Max.
Level	-4	-3	-2	-1	0	1	2	3	4	diff.	diff.
Car / train / BTM / air											
Reference-based		40	53	57	60	63	67	80		3	20
Diff. from base time		*-20*	*-7*	*-3*	*0*	*+3*	*+7*	*+20*			

[34] Each respondent is presented with eight choice pairs within SP1.

[35] The median base time for car, train and local public transport respondents in the NL-2011 survey was 55 minutes, the average base time was 64 minutes.

	Time levels (in min.)									Min.	Max.
Non-reference based	40	45	50	55	60	64	68	75	90	4	50
Diff. from base time	*-20*	*-15*	*-10*	*-5*	*0*	*+4*	*+8*	*+15*	*+30*		

Note that we used different time levels for the reference-based choice pairs and the non-reference-based choice pairs. This is due to the fact that in a reference-based choice pair, the time level of one of the alternatives is always equal to the base level (i.e. level 0). Therefore, the maximum time difference is between the highest (or lowest) time level and the base time level, whereas for the non-reference-based choice pairs the maximum time difference is between the highest and the lowest time level. Given that we wanted to control the BVTT range and this range depended on the maximum time difference (equation [A2]) we needed to use these different levels.

Also note

- In order to get more variations in the non-reference-based choice pairs, we used 9 T-levels. More variation usually reduces correlations in the data set and this will reduce the correlation in the coefficient estimates. For the reference-based choice pairs seven levels were sufficient and filled the BVTT intervals (see Table A6) in a natural way.
- The range of the T-values ran from 40 to 90, which was similar to the ranges used in other European studies (see Section A.3), but was larger than the range in the NL-2009/11 survey (which was relatively small).
- The T-values for the reference-based choice pairs were symmetric around the base levels. In this way, we ensured that the four quadrants (see Figure A1) were covered identically. For the non-reference-based design, this was not a necessity. For those choice pairs, we used more variations in the differences between the time levels of the alternatives.

A.2.5 Step 4b : Set the range of T-values for respondents with other base times

The easiest way to set the range of T-values for respondents with other base times is to scale them proportionally to the levels for a respondent with a 60 minute base time. However, this caused that the range of deltaT (i.e. the difference between the T-level and the base time) scaled proportionally with the base time. Previous studies have shown that the VTT depends both on the base time and on the size of deltaT. If in the design deltaT is highly correlated with the base time, it will be very hard to distinguish the base time effect from the deltaT-effect. Therefore, we needed to 'break' the correlation between deltaT and base time in the design. We did this by using the following table for deltaT depending on base time. Using such a table was similar to the method used in the 2009/11-survey.[36]

Table A8 - Time levels for NL-2022 SP1 experiment for respondent with other BaseTimes

Base time (in min.)	Typical base time	BaseTimeFac Scale factor with respect to base time = 60	deltaT levels (in min.) -4	-3	-2	-1	0	1	2	3	4
Reference-based											
10 – 22	15	0.25		-5	-2	-1	0	+1	+2	+5	
23 – 44	30	0.5		-10	-4	-2	0	+2	+4	+10	
45 – 89	60	1		-20	-7	-3	0	+3	+7	+20	
90 – 179	120	2		-40	-15	-6	0	+6	+15	+40	
180 – 359	240	4		-80	-30	-12	0	+12	+30	+80	

[36] We also have experimented with adding a random term, but simulations showed that the proposed method works better in reducing the correlation.

Base time (in min.)	Typical base time	BaseTimeFac Scale factor with respect to base time = 60	deltaT levels (in min.)								
			-4	-3	-2	-1	0	1	2	3	4
360 – 719	480	8		-160	-60	-25	0	+25	+60	+160	
720+	960	16		-320	-120	-50	0	+50	+120	+320	
Non-reference-based											
10 – 22	15	0.25	-5	-4	-3	-1	0	+1	+2	+4	+8
23 – 44	30	0.5	-10	-8	-5	-3	0	+2	+4	+8	+15
45 – 89	60	1	-20	-15	-10	-5	0	+4	+8	+15	+30
90 – 179	120	2	-40	-30	-20	-10	0	+8	+15	+30	+60
180 – 359	240	4	-80	-60	-40	-20	0	+15	+30	+60	+120
360 – 719	480	8	-160	-120	-80	-40	0	+30	+60	+120	+240
720+	960	16	-320	-240	-160	-80	0	+60	+120	+240	+480

A.2.6 Step 5a : Set the range of C-values for a non-business respondent with a base time of 60 minutes

For the actual levels for the deltaC (difference between the cost value and the base cost, i.e. the travel cost of the reference trip) we used the values in the following table. These values applied to a respondent travelling for a non-business purpose with a base time of 60 minutes.

Table A9 - Cost levels for NL-2022 SP1 experiment for non-business respondent with BaseTime of 60 minutes

	deltaC levels (in €)									Min.	Max.
Level	-4	-3	-2	-1	0	1	2	3	4	diff.	diff.
Car / train / local PT / air											
Reference-based											
Diff. from base cost		-4.50	-2.50	-0.25	0	+0.25	+2.50	+4.50		0.25	4.50
Non-reference based											
Diff. from base cost	-2.00	-1.50	-1.00	-0.40	0.00	+0.60	+1.20	+2.50	+5.00	0.40	7.00

A.2.7 Step 5b : Set the range of C-values for other respondents

For respondents with other base times, the same scale factors applied as in Table A5. In this way, the BVTT range was always the same, irrespective of the base time and base cost.

For respondents in other segments, the deltaC values in Table A9 needed to be multiplied with the BVTTfac from Table A5.

deltaC = deltaC60 x BaseTimeFac x BVTTfac [A4]

A.2.8 Step 5c : Set minimum values for the cost levels

Since the deltaC values only depended on the BaseTimeFac and the BVTTfac and not on the size of the current cost level of the respondent (base cost), it was possible that the cost level (i.e. base cost + deltaC) became very small or even negative. This needed to be prevented by setting the following minimum values:

Table A10 - Cost levels for NL-2022 SP1 experiment for respondent with other BaseTimes

Minimum cost levels (in €)									
Level	-4	-3	-2	-1	0	1	2	3	4
Car / train / BTM / air									
Reference-based		0.25	0.75	0.95	1.00	1.05	1.25	1.75	
					x BaseTimeFac x BVTTfac				
Non-reference based	0.10	0.50	0.75	0.90	1.00	1.05	1.25	1.50	2.00
					x BaseTimeFac x BVTTfac				

A.2.9 Step 6 : Time and cost levels for cycling, walking and recreational navigation

Time and cost levels for cycling and walking were set after careful simulation such that the minimum and maximum BVTT as specified in Table A.5 could be reached, and that values remained realistic. In the design it was arranged that the time for cycling/walking was never shorter than the time for the alternative mode (e-bike/car). In Table A.11 note that either the column for e-bike or for car was used, depending on which alternative mode was chosen. The value in the table was added to the BaseTime, i.e. the travel time of the current trip. In Table A.12 note that the cost for the current mode was always zero.

Table A11 – Delta time levels for NL-2022 SP1 experiment for cycling and walking, to be added to BaseTime.

	Cycling			Walking		
Level	**Cycling**	**E-bike**	**Car**	**Walking**	**E-bike**	**Car**
1	-20	-36	-46	-20	-48	-54
2	-10	-30	-44	-10	-44	-52
3	0	-24	-40	0	-42	-50
4	10	-18	-36	10	-34	-46
5	30	-6	-30	30	-22	-40
	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac

Table A12 – Cost levels for NL-2022 SP1 experiment for cycling and walking

	Cycling		Walking	
Alternative mode	**E-bike**	**Car**	**E-bike**	**Car**
Level				
1	0.30	0.50	0.50	0.50
2	0.80	1.40	1.00	1.00
3	1.40	2.30	2.00	3.00
4	2.80	4.70	4.00	6.00
5	5.60	9.30	6.00	9.00
6	8.40	14.00	12.00	15.00
7	11.20	21.00	24.00	30.00
	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac	x BaseTimeFac

For recreational navigation, we used (waiting) time and cost tables that were independent of current (waiting) time and cost levels.

Table A13 – Waiting time and cost levels for NL-2022 SP1 experiment for recreational navigation

Level	Wait time before bridge / lock (in min.)	Cost per passage (in €)
1	0	0.00
2	5	0.25
3	10	0.50
4	15	1.00
5	30	2.00
6	45	4.00
7	60	8.00

A.2.10 Step 7 : Rounding

All travel times were rounded to the nearest multiple of 1 minute.

All travel costs were rounded to the nearest multiple of € 0,05.

A.2.11 Step 8 : Creating the design tables

In the final step the design table were generated using Ngene. For each segment a candidate set was made consisting of all possible combinations of the time and cost levels for both alternatives. Ngene selected the most efficient set of 8 blocks times 8 choice questions, under the condition that

- each block has 4 reference-based questions (one in each of the four quadrants (EG/EL/WTP/WTA);
- each block has 8 BVTTs that comply with the distribution in Table A6;
- balance of attributes: each attribute level should occur not too often and not too seldomly;
- no dominant questions should occur.

A Federov-algoritm was used to minimize D-error in order to obtain the most efficient design.

A.3 Comparison with other design strategies for time/cost experiments

The designs of the previous time/cost SP experiments in Europe have been very different:

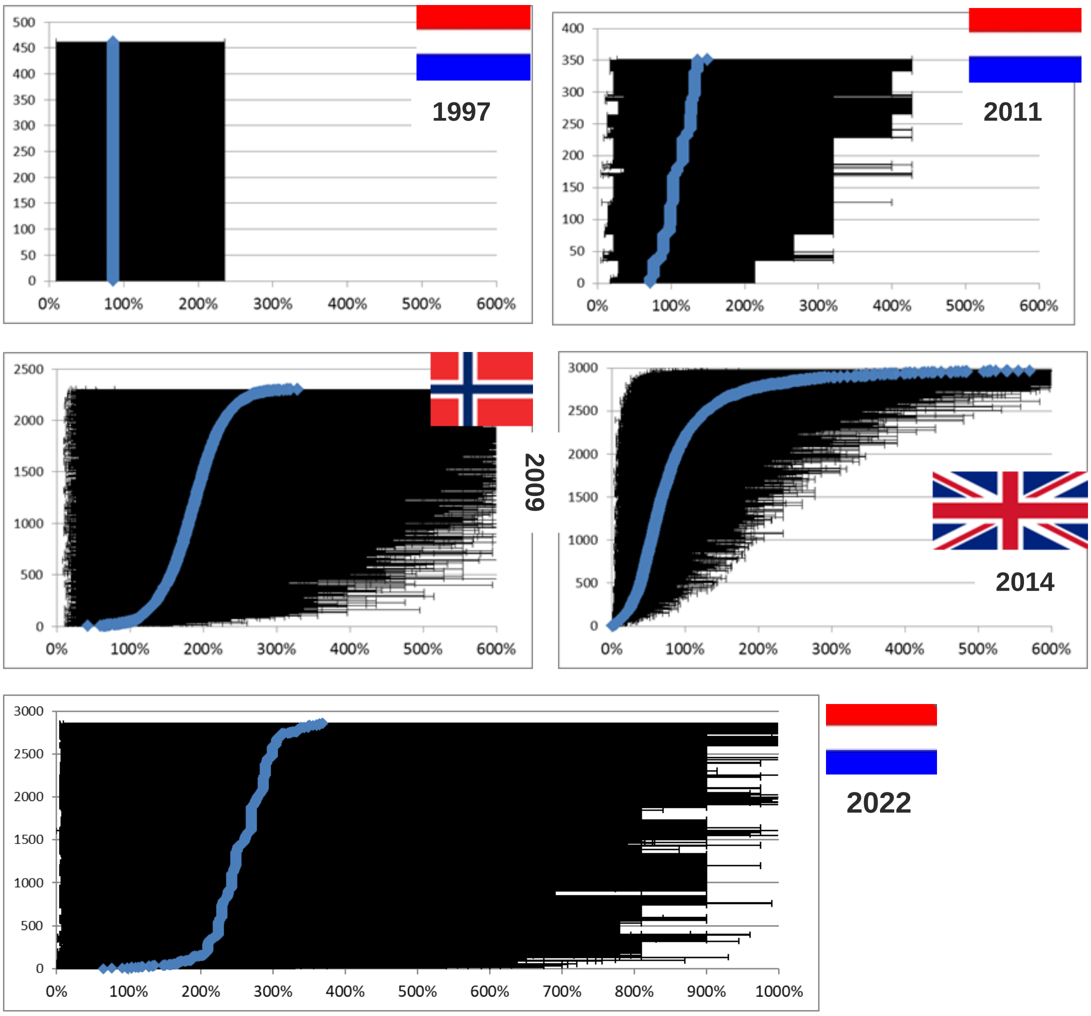
- NL-1988 and NL-1997: fixed set of SP questions pivoted around current travel time / cost (i.e. every respondent got the same set of questions
- NL-2009/2011: "Bradley"-design, i.e. a kind of orthogonal design while preventing dominant questions. Each choice pair was in one of the WTP/WTA/ EG/EL quadrants.
- Sweden-2008: Eight time differences in the 10–30% range of the observed travel time, divided into four strata (2 draws in [10–15%], 2 draws in [15–20%], 2 draws in [20–25%], 2 draws in [25–30%]); Two travel time differences were randomly assigned to each of the four quadrants. Eight VTT bids were drawn from 6 VTT strata in the range 0.5–50 EUR/h (1 draw in [0.5–1.5], 1 draw in [1.5–4], 2 draws in [4–10], 2 draws in [10–20], 1 draw in [20–40] ,1 draw in [40–50]) and assigned randomly to each of the eight time differences. The absolute cost difference was then found for each choice situation by multiplying the absolute time difference by the trade-off value of time. (Börjesson, Fosgerau, & Algers, 2012). We call this the "Scandinavian" design strategy.
- Norway-2009: Similar to Sweden-2008 with slightly different strata. 8 of the 9 questions are in either of the WTP/WTA/EG/EL quadrants.
- UK-2014: D-efficient design. No restriction of the choice pairs to the quadrants
- Norway-2019: Similar to Norway-2009, with slightly different strata, All 8 questions were in the WTP/WTA/EG/EL quadrants.

The design strategies are summarized as follows:

	Design strategy	Reference-based?
NL-1988	Fixed	6 out of 12 choice pairs
UK-1994	Bradley	Yes
NL-1997	Fixed	6 out of 12 choice pairs
Sweden- 2008	Scandinavian	Yes
NL-2009/11	Bradley	Yes
Norway - 2009	Scandinavian	8 out of 9 choice pairs
UK-2014	D-efficient	No
Norway - 2019	Scandinavian	Yes
NL-2022	Combination of Scandinavian and D-efficient	4 out of 8 choice pairs

In the following figures, black lines show the range of the VTT-probed (“boundary VTT”, or BVTT) for each commute-respondent. The blue dots indicate the average VTT-probed for each respondent. Respondents are stacked above each other in the vertical direction (ordered by average VTT-probed). The horizontal axis is the VTT-probed, scaled by the final VTT (= 100%), so that the designs of all surveys can be compared.

From these figures, it is clear that the designs have very different implications for the range of the VTT-probed for the respondents.



The following table compares the ranges for the Time- and Cost-attributes, and for the VTT-probed ("boundary VTT") for a respondent with a reference commute trip of 60 minutes. In the last column, the trading percentages are presented. This is the percentage of respondents that always chose the slowest alternative, the percentage that always chose the quickest and the (remaining) percentage that sometime chose the slowest and sometimes the quickest (i.e. the traders). As can be seen, the new NL-2022 design gives a very high percentage of respondents that trade between the slowest and the quickest alternative.

	Time levels (in min.)	VTT range	Monetary unit	Trading (alw. slow – trading – alw. quick)
NL-1997	40 / 50 / 60 / 70 / 80	0.68 – 16.34	Euro (1997)	1% - 87% - 11%
NL-2011	50 / 55 / 60 / 65 / 75	0.80 – 36	Euro (2011)	16% - 74% - 10%
Sweden- 2008	42 ... 54 / 60 / 66 ... 78	0.50 – 50	Euro (2008)	
Norway - 2009	34... 54 / 60 / 66 ... 87	0.83 – 54	Euro (2009)	16% - 82% - 2%
UK-2014	48 / 55 / 60 / 66 / 78	0.40 - 80	Euro (2014)	16% - 72% - 10%
Norway - 2019	42 ... 54 / 60 / 66 ... 78	1 – 77	Euro (2019)	
NL-2022	40 ... 57 / 60 / 63 ... 90	0.1 – 135	Euro (2022)	5% - 91% - 2%

Appendix B: Methodology to determine the business VTT

B.1 Introduction

In this study, business trips refer to trips made by employees on employer's business, excluding professional drivers (e.g. buses, taxis, lorries) and including blue-collar and white-collar workers, with some focus on briefcase travellers. A special case of business travellers are self-employed persons, where employer and employee refer to the same person.

The value of travel time (VTT) for business travel is a more challenging research topic than for other trip purposes because it is determined by two decision-makers, the employer and the employee. For commuting trips, there may be a financial reimbursement for travel costs by the employer, but these trips usually take place in private time, as is the case for other (non-business, non-commuting) trips.

Several methods for determining the business VTT have been used in various studies in Europe, see Table 69.

Table 69 - Overview of methods to determine the business VTT as used in various studies in Europe

Study (country / year)		Method		
		Hensher-equation (HE)	Cost savings approach (CSA)	Willingness-to-Pay (WTP)
Netherlands	1988	√		
	1997	√		
	2009-2011	√		
Sweden	1994	√		
	2007-2008		√	
Norway	1997	√		
	2009		√	
	2019	√		
UK	1994		√	
	2015			√

All three national VTT surveys in passenger transport in The Netherlands so far (Hague Consulting Group, 1990; Hague Consulting Group, 1998; Significance et al., 2013) have used the so-called 'Hensher Equation' HE (Hensher, 1977) for determining the business VTT. This approach has also been used in Sweden (Algers et al., 1995) and Norway (Ramjerdi et al., 1997). However, in Norway the HE was abandoned in 2009 (but Norway moved to HE again in the 2019 study) and Sweden now only uses the CSA. In the UK, an extensive scoping study was carried out (ITS Leeds et al., 2013; summarised in Wardman et al., 2015) for business travel comparing three different approaches:

- The cost savings approach CSA, that had been used until that time for the official recommendations;
- The HE (in different restricted form variants);

- The Willingness-to-Pay WTP approach, that uses SP and/or RP surveys among employers and/or employees to obtain the values.

ITS Leeds et al. (2013) and Wardman et al. (2015) expressed serious reservations about the further use of CSA. A key problem with this approach is that it does not properly account for the productive use of travel time. The report and the paper did not make a clear-cut choice between HE and WTP, but listed several possible research streams featuring these two approaches and combinations of these, and listed pros and cons. Among the disadvantages of the HE were mentioned: the difficulty of estimating the many coefficients of the HE in practice and different views in the literature on the interpretation of the employee component of the HE. The Department for Transport in its request for proposal for the 2014-2015 national VTT study specifically ruled out the use of the HE. The new UK study (Arup et al., 2015) used the WTP approach.

B.2 The Hensher equation and its foundation

The HE decomposes the business VTT into employee and employer components. It tries to take account of several phenomena, that the cost savings approach ignores (de Jong and Kouwenhoven, 2018):

- The VTT for business travel is determined by the employer and the employee who both receive a benefit;
- The employer component depends on the marginal productivity of work time;
- The employee component also depends of the value of leisure time;
- Some share of the travel time is spent working, though the productivity of this time is not quite as high as that of working at the workplace. When travel time is spent working, this reduces the overall VTT, which is perfectly in line with the underlying theory.

The formulation of the HE that is most widely accepted was first formulated in Fowkes et al. (1986):

$$VBTT = \underbrace{(1 - r - p \cdot q) \cdot MPL + MPF}_{\text{Employer part}} + \underbrace{(1 - r) \cdot VW + r \cdot VL}_{\text{Employee part}} \qquad [B1]$$

where:

VBTT: the business VTT for use in appraisal;

MPL: the productive value of a unit of work time to the employer (the marginal product of labour);

r: the proportion of time savings returned to leisure; the remainder (1-*r*) is spent as work in the workplace;

p: the proportion of travel time saved that is at the expense of time spent working during the trip;

q: relative productivity of work undertaken while travelling (relative to working at the workplace);

MPF: the value of extra production as a result of reduced travel fatigue;

VW: the value to the employee of work time at the workplace relative to travel time;

VL: the value to the employee of leisure time relative to travel time.

The first two components on the right-hand side are for the employer, the third and fourth component are for the employee.

The HE can be derived from micro-economic theory (Batley, 2015). This involves the maximisation of a welfare function, consisting of the sum of the employer's profit (revenues from selling goods, produced with labour time inputs at some productivity, minus labour costs; in utility terms) and the employee's utility (depending on goods consumed, and work, leisure and travel time). This maximisation takes place conditional on a time budget, but without specifying an explicit money budget. The HE is therefore not some convenient ad hoc equation, but has a theoretical foundation. This however does not guarantee that employers and employees will follow these rules in their decision-making in practice, or that this rule can adequately explain their choices. This in an empirical question.

B.3 The national and international literature on the business VTT

The HE has a large number of coefficients that need to be determined for calculating the VTT for business travel: *r*, *p* and *q*, as well as the marginal productivity of labour *MPL*, the relative value to the employee of work time at the workplace *VW* and the relative value to the employee of leisure time *VL*. *MPF* in empirical studies is always omitted as being not so important and very difficult to measure.

ITS Leeds et al. (2013) and Wardman et al. (2015) review eleven studies in Europe (including the three from The Netherlands), Australia and New Zealand that have tried to determine these unknowns to populate the HE. The approach used in these studies consists of surveying business travellers and asking them questions on their business trips and what they would do in case of time savings. Then the values for *r*, *p* and *q* are calculated directly as a weighted or unweighted average from the answers given by the sample of business travellers. An important issue here is whether these samples of business travellers are sufficiently large and representative for the derivation of these coefficient values through simple averaging (or with a weighting from a national travel survey). An alternative would be to model these coefficients as endogenous variables depending on individual and trip attributes (as suggested in ITS Leeds et al., 2013), but this has not been pursued so far.

Most of the studies (including the Dutch ones) provide not p, which relates to travel time saved (at the margin), but p*, the average fraction of the journey time that is spent working. The assumption made here is that average values are good approximations for the marginal values.

The marginal product of labour usually comes from national accounts or data on wages and labour costs for employers (again usually taking the average value, not that at the margin).

The value of productive work during the journey can differ between modes (there is more scope for it in the train than in the bus or the car; also this could differ between types of train, such as intercity and local/regional stop trains).

The differences in interpretation between countries, that have implemented the HE, mainly arise in relation to the employee components $(1 - r) \cdot VW + r \cdot VL$. The derivation of r has been discussed above; *VW* and/or *VL* in the empirical work come from SP experiments (which can be phrased in different ways) among business travellers.

B.3.1 The Dutch VTT studies

In the Dutch national VTT studies there is only a single variable for the employee component; the HE reduces to:

$$VBTT = (1 - r - p \cdot q) \cdot MPL + VP \qquad [B2]$$

where:

VP: the (weighted) average VTT from the employees without distinguishing what people do with their time savings (either take more work [(1 - r) · VW] or more leisure more [r · VL]).

The SP experiments for business travel in the three Dutch national VTT studies carried out so far tried to find the valuation of the time savings for the employees themselves, not including that of the employer (which comes from the marginal product of labour). The Dutch VTT studies make the assumption that the VTT that results from the SP experiment for business travel represents whatever people do when they save time on a business trip, without making this explicit[37].

John Bates, in a correspondence on how the HE results in the latest Dutch VTTR study should be represented in ITS Leeds et al., (2013) and Wardman et al. (2015) suggested a test making the distinction between *VW* and *VL* (he assumed *VW*<*VL*). This is possible on the SP data collected in 2011,

[37] This restricted version of the HE arises by definition if we assume *VW*=*VL* (and omit the travel fatigue effect *MPF*).

since a question was asked what the respondent would do with the time savings (the options including working as well as leisure). The same question was asked in the 2022 VTT/VTTR survey.

B.3.2 Norway and Sweden

Both Norway and Sweden used HE for a number of years, but moved to the CSA (using gross wages) in the period 2008-2010.

When Norway still used HE (Ramjerdi et al, 1997), a different way of restricting the full HE than in The Netherlands was used. The assumption was made that business travellers place no premium or discount on the value of travel time relative to the value of working time at the work place (also that *VW* does not include the wage). This implies that *VW*=0. The HE becomes (also omitting *MPF*):

$$VBTT = (1 - r - p \cdot q) \cdot MPL + r \cdot VL \qquad [B3]$$

VL comes from the SP experiment among business travellers that focusses on the employee's own valuation. Note that this employee VTT is weighted by *r*, unlike equation [B2].

Instead of doing an SP experiment among business travellers about their own valuation to obtain *VL*, one could also use the VTT results for the travel purpose 'other' (which includes leisure), but with proper re-weighting to correct for differences in the characteristics of business travellers and their trips on the one hand and travellers for non-business, non-commuting on the other hand.

Sweden (Algers et al., 1995) used the same specification of the HE as The Netherlands (eq. [B2]).

The main reason for abandoning the HE for business travel in Sweden and Norway was the expectation that in the long run workers would not use saved travel time for leisure but that travel time savings would increase the work time (ITS Leeds et al., 2013). Under this expectation, *r* becomes zero and when one also assumes that *VW*=0 the HE becomes:

$$VBTT = (1 - p \cdot q) \cdot MPL \qquad [B4]$$

This is equivalent to the cost savings approach with a correction for productive work and its relative productivity.

The idea is that when an employee travels for business purposes within the regular working hours, time savings will be used for work time, and outside the regular working hours it is part of the deal between employer and employee that this is paid work time. Moreover, empirical data does not show a decrease in leisure time spent on business trips over time in spite of increases in travel speed. An SP survey for a particular trip can be thought of to represent the short-run, whereas the long-run effect is required. The empirical evidence for r comes from the national VTT surveys and leads to a value for *r* (which could be only for the short-run) of around 0.5 (Wardman et al., 2015).

B.3.3 The latest UK VTT study

The new UK study (Arup et al., 2015) used for business travel the WTP approach. This means that the VTT is not build up bottom-up distinguishing employer and an employee components, but that an attempt is made to estimate a single overall VTT, that takes account of all the relevant considerations, by using choice observations (RP or SP) from employers or employees. The UK study collected RP data and SP data for business travel from employees and SP data from employers. In the employees SP, the aim was to get employees to respond in accordance with the company's interest. Both SPs gave similar values and it was decided to determine the official values on the basis of the SP among employees, because this was a much larger dataset with more robust estimation results, that could also be expanded using the National Travel Survey NTS (Batley et al., 2018).

B.4 Implications for the 2022 Dutch VTT study

Several methods are available for determining the business VTTS, each with their own assumptions and implications for the questionnaire, including the SP experiments. On the basis of the recent literature, we can dismiss the CSA, as it does not properly account for productive travel time. There is no compelling evidence to select a single alternative approach from the remaining alternatives at the start of this new project. Apart from the arguments given above, there is also the argument of consistency with the previous national VTT surveys in The Netherlands, which calls for repeating the previous HE method using eq. [B2]. The recent international literature leads us to have a slight preference for a direct WTP approach using an SP among business travellers[38], but for comparison results from the approach that was used in the previous three Dutch surveys are needed as well. It would be good, both for obtaining credible results in The Netherlands and for VTT research more in general to compare different methods empirically.

Therefore, various options in terms of the approach were kept open. This implied:

- the questions on *MPL*, *r*, *p* and *q* were kept in the business questionnaire, as input for HE calculation on the expanded sample (using the National Travel Survey for the targets) using equations [B2], which is the approach used in The Netherlands before, [B3] and [B4].
- an SP experiment among business travellers was carried out:
  - it was intended that 50% of the business travellers (internet panel and en-route) was asked to assume that this trip is in their own time and for their own money, so that we can estimate *VP* from eq. [B2].
  - And it was intended that 50% of the business travellers (internet panel and en-route) was asked to include the employer perspective/company policy (using wording similar to that in the latest UK survey as cited above), so that a VTT according to the WTP approach could be estimated. For self-employed business travellers, we concluded that the employer's perspective will be best represented in the employee's choices, so this group can be used for benchmarking.
- *VP* and *VL* from the business travellers' sample will be compared to the VTT from those traveling for 'other' purposes, by expanding the latter results to represent business travel characteristics, such as distance and income (from the Dutch NTS).
- In the derivation of VP, we will test whether there are differences between those who translate time savings into leisure time (*VL*) and into work time (*VW*). This required that we kept the questions on what the time savings would be used for. This also allows us to determine $r \cdot VL$.
- A survey among employers was not be carried out, given that this would have been difficult in practice and relatively expensive, and that in the UK the VTT from the employee SP was similar to that from the employer SP (Arup et al., 2015) and was used for the official values.

At the beginning of the project, it was decided that if both methods would lead to plausible results, it would be recommended to use the results from the WTP method, given the slight preference for this method based on the international literature (see earlier in this section)[39].

B.5 Implementation in the 2022-survey

After filtering, the survey contains data from 1495 respondents who made a business trip.

A random draw was done to determine whether they would be selected for the HE methodology. This random draw was stored in the variable USEHENSHER:

USEHENSHER	Number of respondents
FALSE	734
TRUE	761

[38] This preference is based on the disadvantages of the HE approach (it needs many coefficients which are difficult to estimate; there are different interpretations for the employees component; asking the employee to elicit the full business VTT in a choice experiment instead of doing the choice experimenty for only a part of the VTT, where the remainder is calculated on the basis of the marginal productivity of labour, reduces the probability of double counting or omitting components) and on the fact that the UK recently did not select HE but WTP, whereas other countries have moved away from HE. The disadvantages of the WTP approach are that there is little experience with using this approach for the business VTT and that this experience is limited to the UK, where train fares are much more variable (depending on time of day and moment of booking) and which has charges for entering environmental zones in road transport.

[39] On the other hand, if we would find that the WTP values from employees are implausibly low, this might be an indication that the employees did not properly include all the time benefits to the employers in their trading between choice alternatives in the SP experiments. In this specific case we would rather use the HE outcomes.

USEHENSHER	Number of respondents
Total	1495

Next, respondents were asked whether they had salaried work or if they were self-employed.

PAID_EMPLOYMENT	Number of respondents With USEHENSHER = FALSE	Number of respondents With USEHENSHER = TRUE
Salaried work	586	619
Self-employed	148	142
Total	734	761

The 586 respondents with salaried work and USEHENSHER = FALSE were asked whether their employer would be willing to pay more money to shorten their travel time.

DECISION_BY_EMPLOYER	Number of respondents
Yes, my employer would certainly be willing to do that.	73
Yes, but only if the benefits of the time saved outweigh the higher travel costs.	151
No, my employer would not be interested in paying more to reduce travel time.	362
Total	586

Depending on the combination of these variables, the following instructions were given before the SP, and repeated for each SP question:

GROUP	USE HEN- SHER	PAID_ EMPLOY MENT	DECISION_ BY_ EMPLOYER	Numb. of res- pond- ents	Instruction before SP	Instruction at each question
1	TRUE	Any	(not asked)	761	Bij alle keuzes moet u zich de volgende dingen voorstellen: - dat u in uw eigen tijd reist - dat alle kosten voor uw eigen rekening komen	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.
2	FALSE	Salaried work	Yes (certainly, or only if benefits outweigh costs)	224	Eerder zei u dat uw organisatie bereid is om te betalen om uw reistijd te verkorten. Wilt u bij de volgende keuzes de belangen van uw organisatie meewegen.	Weeg de belangen van uw organisatie mee.
3			No	362	Eerder zei u dat uw organisatie niet bereid is om te betalen om uw reistijd te verkorten. Wilt u ervan uitgaan dat u in uw eigen tijd reist en dat alle kosten voor uw eigen rekening komen.	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.
4		Self employed	(not asked)	148	Wilt u bij de volgende keuzes de belangen van uw eigen bedrijf meewegen.	Weeg de belangen van uw eigen bedrijf mee.

Same table with translated instructions:

<table>
<tr><th>GROUP</th><th>USE HEN-SHER</th><th>PAID_ EMPLOY MENT</th><th>DECISION_ BY_ EMPLOYER</th><th>Numb. of res-pond-ents</th><th>Instruction before SP</th><th>Instruction at each question</th></tr>
<tr><td>1</td><td>TRUE</td><td>Any</td><td>(not asked)</td><td>761</td><td>With all choices, you should imagine the following things:
- that you travel on your own time
- that all costs are for your own account</td><td>Assume you are traveling on your own time.
Assume that all costs are for your own account.</td></tr>
<tr><td>2</td><td rowspan="3">FALSE</td><td rowspan="2">Salaried work</td><td>Yes (certainly, or only if benefits outweigh costs)</td><td>224</td><td>Earlier you said that your organization is willing to pay to reduce your travel time. Please take the interests of your organization into account when making the following choices.</td><td>Take the interests of your organization into account.</td></tr>
<tr><td>3</td><td>No</td><td>362</td><td>Earlier you said that your organization is not willing to pay to reduce your travel time. Please assume that you travel on your own time and that all costs are for your own account.</td><td>Assume you are traveling on your own time.
Assume that all costs are for your own account.</td></tr>
<tr><td>4</td><td>Self employed</td><td>(not asked)</td><td>148</td><td>Please take the interests of your own company into account when making the following choices.</td><td>Consider the interests of your own company.</td></tr>
</table>

A priori, we had the following expectations for the VBTT:

- GROUP 1: employee-part of VBTT, similar to the one obtained in 2009/2011 survey
- GROUP 2: sum of employee + employer part of VBTT, so expect to be higher than for GROUP1
- GROUP 3: instructions are the same as for GROUP 1, so similar value is expected
- GROUP 4: sum of employee + employer part of VBTT, so expect to be higher than for GROUP1 but it may not be as high as for GROUP 2

(taking into account the uncertainty intervals for each VBTT).

B.6 Results for estimation of the GROUP-interaction coefficient of the VBTT

B.6.1 Results for NL-2022 study

We developed (separately) the optimal utility function for car, train, local public transport and air.

In the final estimation, we added additional interaction coefficients for each of the GROUPs of business travellers that got separate instructions (as specified above). These were interaction coefficients that need to be applied on top of the business interaction coefficient. The relevant part of the utility function that was used is (see Section §8.1.1 for a full description of the utility function):

```
Util   ~   μ · ( COST + vtt_ref · TIME ·
                          (1 + cf_purp2 * IS_PURPOSE2 * ( 1 + cf_he_vtt  * IS_GROUP1
                                                         + cf_wtp2_vt * IS_GROUP2
                                                         + cf_wtp4_vt * IS_GROUP4 )
                             + cf_purp3 * IS_PURPOSE3                                 )
```

in which IS_PURPOSE2 and IS_PURPOSE3 are dummies that indicate whether the trip purpose is business or other, respectively (yes = 1, no = 0), and where IS_GROUP1/2/4 are dummies that indicate whether the GROUP variable is 1,2 or 4.

The results of the full estimations are (only relevant parameters are shown):

	CAR		TRAIN		LOCAL PT		AIR	
mu	-0.8423	(-23.1)	-1.088	(-21.5)	-1.084	(-22.0)	-0.04149	(-26.9)
vtt_ref	7.828	(15.9)	9.994	(18.6)	8.468	(15.7)	38.49	(18.5)
cf_purp2	0.4181	(4.1)	0.2000	(1.6)	0.1748	(1.3)	0.09346	(1.1)
cf_purp3	-0.1285	(-2.7)	-0.1397	(-3.3)	0.04692	(0.7)		
cf_he_vtt	0.2071	(0.6)	0.4651	(0.4)	1.670	(0.8)	2.358	(0.8)
cf_wtp2_vt	3.397	(3.1)	5.563	(1.3)	11.22	(1.2)	8.706	(1.0)
cf_wtp4_vt	0.7888	(1.3)	3.843	(1.0)	5.029	(0.9)	8.653	(0.9)

In this (simplified) utility formulation

- vtt_ref is the value of travel time for a (reference) person making a commute trip
  - this is a traveller with PURPOSE = 1
- the value of travel time for a business traveller of group 3 is vtt_ref · (1 + cf_purp2)
  - this is a traveller with PURPOSE = 2 and GROUP = 3
- the vtt for a (reference) business traveller of group 1 is vtt_ref · (1 + cf_purp2 · (1 + cf_he))
- the vtt for a (reference) business traveller of group 2 is vtt_ref · (1 + cf_purp2 · (1 + cf_wtp2_vt))
- the vtt for a (reference) business traveller of group 4 is vtt_ref · (1 + cf_purp2 · (1 + cf_wtp4_vt))

So, we have for the value of business travel time for a reference person:

	CAR	TRAIN	LOCALPT	AIR
vbtt_ref_group1	11.78	12.92	12.42	50.57
vbtt_ref_group2	22.22	23.11	26.56	73.41
vbtt_ref_group3	11.10	11.99	9.95	42.09
vbtt_ref_group4	13.68	19.67	17.39	73.21

Indeed, vbtt for group 2 is highest; for group 1 and 3 are about equal (and lowest), and for group 4 are in between.

Note that average vtt values for these groups can only be obtained after a (weighted) sample enumeration.

Further estimations reveal that for car, train, and local pt cf_he_vtt (i.e. the interaction coefficient for Hensher respondents) was not significantly different from zero, so we have constrained them to be to zero (i.e. constrain the vtt for groups 1 and 3 to be the same) For air, cf_he_vtt was significantly different from zero, however, because of consistency between the modes, we have decided to also constrain it to zero for air as well.

Final estimates:

	CAR		TRAIN		LOCAL PT		AIR	
mu	-0.8412	(-23.0)	-1.088	(-21.5)	-1.083	(-22.0)	-0.04151	(-26.9)
vtt_ref	7.843	(15.9)	9.998	(18.6)	8.452	(15.7)	38.51	(18.4)
cf_purp2	0.4716	(5.9)	0.2671	(2.8)	0.3238	(2.8)	0.2598	(4.0)
cf_purp3	-0.1298	(-2.7)	-0.1403	(-3.3)	0.04664	(0.7)		
cf_wtp2_vt	2.893	(4.1)	3.930	(2.0)	5.625	(2.1)	2.483	(2.8)
cf_wtp4_vt	0.5579	(1.2)	2.622	(1.2)	2.255	(1.1)	2.504	(1.8)

So, we have for the value of business travel time for a reference person:

	CAR	TRAIN	LOCALPT	AIR
vbtt_ref_group1	11.54	12.67	11.19	48.51
vbtt_ref_group2	22.24	23.16	26.58	73.36
vbtt_ref_group3	11.54	12.67	11.19	48.51
vbtt_ref_group4	13.61	19.67	17.36	73.57

B.6.2 Comparison with the UK-2014 study

Quote from UK-report (Section 6.5.2):

> *Adopting the position where the company 'would pay if the benefits exceeded the costs' as the base, the VTT was 30% higher for car users who stated that the company 'would pay come what may', and 56% lower for those who stated that their company 'would not be interesting in buying a time saving' (in this case, respondents were instructed to assume they would pay themselves). Encouragingly, the latter figure is broadly in line with the difference between the VTTs for work and non-work trips that we have estimated in the course of the present study.*

Note that they estimated separate coefficients for each of the answer categories to the question on whether their employer would be willing to pay for a shorter travel time, whereas we have combined the levels "yes, always", and "yes, if the benefits are larger than the costs".

B.7 Results for the employer VBTT (Hensher equation, unweighted)

Note that the questions regarding the Hensher equation components were asked to all business respondents, so we have calculated these parameters for all groups of respondents.

Table 70 - Number of respondents

	Group 1	Group 2	Group 3	Group 4	All
Car	246	55	141	45	487
Train	108	34	52	18	212
Bus, tram, metro	90	17	51	14	172
Air	175	95	44	26	340
Cycling	76	11	47	23	157
Walking	64	11	27	22	124
Recr. navigation	0	0	0	0	0
Total	759	223	362	148	1492

Table 71 - Percentage of travel time spent working (p)

	Group 1	Group 2	Group 3	Group 4	All
Car	7.9%	12.9%	9.4%	15.2%	9.6%
Train	13.0%	13.7%	11.9%	10.2%	12.6%
Bus, tram, metro	5.3%	6.0%	7.3%	7.1%	6.1%
Air	12.3%	16.1%	5.7%	13.8%	12.6%
Cycling	1.0%	1.5%	2.1%	0.0%	1.2%
Walking	9.7%	23.3%	11.2%	0.8%	9.6%
Recr. navigation					
Total	8.8%	13.8%	8.2%	9.1%	9.4%

Table 72 - Relative productivity of work during travel (q)

	Group 1	Group 2	Group 3	Group 4	All
Car	98.8%	93.9%	94.5%	100.0%	97.0%
Train	88.6%	87.2%	87.6%	100.0%	88.9%
Bus, tram, metro	90.8%	93.3%	89.3%	100.0%	90.9%
Air	86.7%	89.2%	85.8%	93.5%	88.3%
Cycling	100.0%	100.0%	66.7%		91.7%
Walking	99.5%	100.0%	83.3%	100.0%	95.8%
Recr. navigation					
Total	92.7%	91.3%	90.2%	97.7%	92.3%

Table 73 - Percentage saved time that would be spent working (1-r)

	Group 1	Group 2	Group 3	Group 4	All
Car	41.5%	49.1%	39.4%	26.7%	40.3%
Train	23.6%	29.4%	28.8%	41.7%	27.4%
Bus, tram, metro	21.7%	29.4%	23.5%	28.6%	23.5%
Air	20.6%	21.6%	17.0%	40.4%	21.9%
Cycling	19.1%	36.4%	29.8%	28.3%	24.8%
Walking	35.9%	63.6%	24.1%	4.5%	30.2%
Recr. navigation					
Total	29.1%	33.0%	30.5%	28.0%	30.0%

Table 74 - Marginal productivity of labour by mode (MPL), also known a the productive value of a unit of work time, in € per hour.

	Group 1	Group 2	Group 3	Group 4	All
Car	43.35	38.12	44.20	56.38	44.21
Train	48.86	46.28	53.76	32.72	48.28
Bus, tram, metro	42.89	41.19	64.91	35.91	48.68
Air	47.19	44.44	42.88	57.17	46.63
Cycling	57.86	33.84	44.18	50.08	50.94
Walking	41.11	49.05	54.64	51.54	46.61
Recr. navigation					
Total	46.23	42.62	49.11	50.01	46.76

Table 75 - Value of business travel time (VBTT), in euro/hr

	Group 1	Group 2	Group 3	Group 4	All
Car	14.57	13.86	14.09	6.68	13.62
Train	5.68	8.31	11.53	11.24	8.01
Bus, tram, metro	8.56	8.57	13.51	6.47	9.86
Air	1.85	1.72	6.50	20.22	3.82
Cycling	7.97	8.24	13.94	11.38	10.27
Walking	8.80	25.73	5.89	1.17	8.32
Recr. navigation					
Total	8.51	7.75	12.09	9.50	9.36

In the following tables, a comparison is made with the previous surveys. The 2022 numbers in the following tables are based on the Total-columns in the previous tables (i.e. average over respondents of all groups).

Table 76 - Number of respondents

	1997	2011	2022
Car	866	246	487
Train	226	41	212
BTM	69	11	172
Airplane		26	340
Total	1161	324	1211

Table 77 - Fraction of journey time spent working by mode

	1997	2011	2022
Car	3.5%	3.6%	9.6%
Train	16.1%	15.7%	12.6%
BTM	2.6%	6.0%	6.1%
Airplane		13.6%	12.6%

Table 78 - Relative productivity of work during travel by mode

	1997	2011	2022
Car	93.1%	90.5%	97.0%
Train	90.3%	94.0%	88.9%
BTM	88.9%	83.3%	90.9%
Airplane		100.0%	88.3%

Table 79 - Percentage of saved time that would be spent working by mode

	1997	2011	2022
Car	54.5%	55.9%	40.3%
Train	37.0%	37.8%	27.4%
BTM	34.1%	54.5%	23.5%
Airplane		21.2%	21.9%

Table 80 - Productive value of a unit of work time by mode in € (different price levels, as indicated)

	1997 (€-2010)	2011 (€-2010)	1997 (€-2022)	2011 (€-2022)	2022 (€-2022)
Car	34.84	31.17	46.19	41.33	44.21
Train	27.26	37.78	36.14	50.09	48.28
BTM	21.12	33.14	28.00	43.94	48.68
Airplane		39.12		51.87	46.63

CBS Statline: CPI(2010) = 91.59; CPI(2022) = 121.43

Note the apparent decline for train and airplane. Might be related to the after-effects of the COVID-pandemic, might be related to the inflation that is already included in these CPI, but not yet in the salaries.

Table 81 - Value of Business Travel Time, according to method base on averages, in € (different price levels, as indicated). Note that these are not the official VTTs for business. Those are determined using the sample enumeration.

	1997 (€-2010) Method based on averages	2011 (€-2010) Method based on averages	1997 (€-2022) Method based on averages	2011 (€-2022) Method based on averages
Car	18.31	16.41	24.28	21.76
Train	5.14	8.71	6.81	11.55
BTM	8.16	16.43	10.82	21.78
Airplane		2.97		3.94

CBS Statline: CPI(2010) = 91.59; CPI(2022) = 121.43

Note that the 2009/2011 report includes two values for the VBTT. The first (Table 58) based on averages, and the second (Table 59) based on the weighted sample enumeration (rounded to the nearest multiple of 0.25). The latter is not available for 1997.

B.8 Final calculations for 2022

We calculated the VBTT using the Hensher method (GROUP1) and the WTP method (GROUP234). For GROUP 3, we assumed that the employer part of the VBTT equals to zero. The sample enumeration was performed based on the combined internet panel and intercept samples. The resulting VBTT are weighted by travel time.

Table 82 – Comparison VBTT for HE and WTP method,

	GROUP 1 (HE) Employee	GROUP 1 (HE) Employer	GROUP 1 (HE) Total	GROUP 234 (WTP) Total	Rel. diff. WTP vs. HE
Car	16.56	15.07	31.63	21.20	*-32%*
Train	16.07	6.99	23.06	17.96	*-22%*
BTM	10.29	9.98	20.27	14.39	*-29%*
Air	73.63	4.53	78.16	110.22	*+41%*

Table 83 – Comparison VBTT for HE between 2022 and 2010 survey

	GROUP 1 (HE) Total	VTT 2010 (price level 2022)	Relative difference
Car	31.63	34.00	*-7%*
Train	23.06	25.58	*-11%*
BTM	20.27	24.61	*-21%*
Air	78.16	111.08	*-30%*

Appendix C: SP instructions

The following tables contain all instructions that were given

- Prior to SP1A/B/C (Table 84)
- During SP1A/B/C (i.e. shown with each choice situation, see Table 85)
- Prior to SP2A/B/C (Table 86)
- During SP2A/B/C (i.e. shown with each choice situation, see Table 87)
- Prior to SP3A/4A (Table 88)
- During SP3A/4A (i.e. shown with each choice situation, see Table 89)
- Prior to SP5A/6A (Table 90)
- During SP5A/6A (i.e. shown with each choice situation, see Table 91)

Table 84 – Instructions before SP1A/B/C

Mode filter						Additional filter	Text Dutch	Text English
CAR							We gaan zo dadelijk steeds twee ritten presenteren, waarin de reistijd en kosten veranderd zijn. Bijvoorbeeld:	We are going to present two trips repeatedly, the travel times and costs of the trips have changed. For example:
	PT						We gaan zo dadelijk steeds twee ritten presenteren, waarin de (deur-tot-deur) reistijd en kosten veranderd zijn. Bijvoorbeeld:	We are going to present two trips repeatedly, the (door-to-door) travel times and costs of the trips have changed. For example:
		NAV					We gaan zo dadelijk steeds twee routes presenteren, waarin de gemiddelde wachttijd en kosten per passage veranderd zijn. Bijvoorbeeld:	We are going to present two routes repeatedly, the average waiting time and cost per passage have changed. For example:
			AIR				We gaan zo dadelijk steeds twee vluchten presenteren, waarin de reistijd en kosten veranderd zijn. Bijvoorbeeld:	We are going to present two flights repeatedly, the travel times and costs of the flights have changed. For example:
				CYC			We presenteren zo dadelijk steeds twee opties voor het bereiken van uw bestemming waarbij de vervoerwijze, kosten en reistijd van elkaar verschillen. Bijvoorbeeld:	
					WLK		We presenteren zo dadelijk steeds twee opties voor het bereiken van uw bestemming waarbij de vervoerwijze, kosten en reistijd van elkaar verschillen. Bijvoorbeeld:	
							VOORBEELD KEUZESCHERM	EXAMPLE CHOICE SCREEN
CAR							U mag zich hierbij voorstellen dat u uit twee verschillende routes kunt kiezen.	Imagine that you can choose between two different routes.
	PT						U mag zich hierbij voorstellen dat u uit twee verschillende dienstregelingen kunt kiezen.	Imagine that you can choose between two different schedules.
			AIR				U mag zich hierbij voorstellen dat u uit twee verschillende vluchten kunt kiezen.	Imagine that you can choose between two different flights.
				CYC		ACTIVE_ALTMODE_SP = EBIKE AND BIKETYPE = (3 OR 5)	Neem aan dat u uw elektrische fiets niet ter beschikking heeft, maar in plaats daarvan wel een gewone fiets heeft. U mag zich hierbij voorstellen dat u tussen een route met uw eigen (gewone) fiets of een route met een gehuurde elektrische fiets kunt kiezen.	Assume that your electric bike is not available, but you do have a regular bike available. Imagine that you can choose between a route with your own (regular) bike and a route with a hired electric bike. The electric bike can be picked up close to your origin address.
				CYC		ACTIVE_ALTMODE_SP = EBIKE AND BIKETYPE != (3 OR 5)	U mag zich hierbij voorstellen dat u tussen een route met uw huidige fiets of een route met een gehuurde elektrische fiets kunt kiezen.	Imagine that you can choose between a route with your current bike and a route with a hired electric bike.
					WLK	ACTIVE_ALTMODE_SP = EBIKE	U mag zich hierbij voorstellen dat u lopend kunt gaan of een elektrische fiets kunt huren.	Imagine that you can choose between walking or hiring an electric bike.
				CYC	WLK	ACTIVE_ALTMODE_SP = EBIKE	De elektrische fiets kunt u vlakbij uw vertrekadres ophalen en vlakbij uw aankomstadres inleveren. De huurkosten voor de elektrische fiets zijn voor 1 rit.	The electric bike can be picked up close to your origin address and handed in close to your destination address. The renting costs of the electric bike are for 1 trip.
				CYC		ACTIVE_ALTMODE_SP != EBIKE	U mag zich hierbij voorstellen dat u een route met uw fiets of een route met de [ACTIVE_ALTMODE_SP] kunt nemen.	Imagine that you can choose between a route with your bike and a route by [ACTIVE_ALTMODE_SP].

					WLK	ACTIVE_ALTMODE_SP != EBIKE	U mag zich hierbij voorstellen dat u lopend kunt gaan of een route met de [ACTIVE_ALTMODE_SP] kunt nemen.	Imagine that you can choose between walking and a route by [ACTIVE_ALTMODE_SP].
CAR							- de **reistijd** kan verschillen bijvoorbeeld omdat de ene rit **korter** is, of **minder files** heeft (en **niet** doordat u **harder rijdt**),	- the **travel time** can vary, for example, because one trip is **shorter** or **less congested** (and **not** because you **accelerate more quickly),**
	PT						- de deur-tot-deur **reistijd** kan verschillen per dienstregeling,	- the door-to-door **travel time** can differ per schedule,
			AIR				- de **reistijd** kan verschillen bijvoorbeeld omdat het ene vliegtuig via een **kortere route** vliegt,	- the **travel time** can vary, for example, because one airplane flies a **shorter route,**
				CYC		ACTIVE_ALTMODE_SP = EBIKE	- de **reistijd** kan verschillen bijvoorbeeld doordat de ene route **korter** is (en **niet** doordat u **harder trapt**).	- the **travel time** can vary, for example, because one route is **shorter** (and **not** because you are **pedaling with more power**).
CAR							- de **kosten** kunnen verschillen bijvoorbeeld doordat u bij de ene rit **minder brandstof** verbruikt.	- the **costs** can vary, for example, because one trip requires **less fuel.**
	PT						- de **kosten** kunnen verschillen bijvoorbeeld omdat het ene OV-kaartje goedkoper is.	- the **costs** can vary, for example, because one public transport ticket is cheaper.
			AIR				- de **kosten** kunnen verschillen bijvoorbeeld omdat het ene ticket goedkoper is.	- the **costs** can vary, for example, because one flight ticket is cheaper.
			AIR				De kosten die getoond worden zijn **voor een enkele reis**.	The costs that are shown are **for a single trip**.
			AIR				Steeds vragen we u welke reis uw voorkeur heeft.	We ask you each time which journey you prefer.
CAR	PT			CYC			Steeds vragen we u welke rit uw voorkeur heeft.	We ask you each time which trip you prefer.
					WLK		Steeds vragen we u welke verplaatsing uw voorkeur heeft.	We ask you each time which trip you prefer.
PAGE BREAK								
CAR	PT	NAV	AIR	CYC	WLK		Bij alle keuzes moet u zich de volgende dingen voorstellen:	For each choice, assume the following:
CAR	PT			CYC			- dat **beide** ritten **mogelijk** zijn (ook als ze onrealistisch lijken),	- **both** trips are **feasible** (even if they seem unrealistic),
		NAV					- dat **beide** routes **mogelijk** zijn (ook als ze onrealistisch lijken),	- **both** routes are **feasible** (even if they seem unrealistic),
			AIR				- dat **beide** vluchten **mogelijk** zijn (ook als ze onrealistisch lijken),	- **both** flights are **feasible** (even if they seem unrealistic),
					WLK		- dat **beide** verplaatsingen **mogelijk** zijn (ook als ze onrealistisch lijken),	- **both** trips are **feasible** (even if they seem unrealistic),
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = TRUE	- dat u **in uw eigen tijd** reist,	- you travel **in your own time**,
CAR	PT		AIR	CYC	WLK	(PURPOSE != BUSINESS & EMPPAY != 4) (respondent does not receive travel cost reimbursement) OR	- dat alle kosten **voor uw eigen rekening** komen,	- all costs are **for your own account**,

CAR	PT	NAV	AIR	CYC	WLK	Condition	Dutch	English
						(PURPOSE = BUSINESS & HENSHER = TRUE)		
CAR							- dat alle andere kenmerken van beide ritten gelijk zijn (even veilig, even mooi, parkeerkosten even hoog etc.),	- all other characteristics are equal for both trips (equally safe, equally pretty, parking costs are equal, etc.),
	PT						- dat alle andere kenmerken van beide ritten gelijk zijn (zelfde comfort, even veilig, even mooi, etc.),	- all other characteristics are equal for both trips (equally comfortable, equally safe, equally pretty, etc.),
		NAV					- dat alle andere kenmerken van beide routes gelijk zijn (even veel bruggen en sluizen, even mooi, even druk),	- all other characteristics are equal for both routes (the same number of bridges and locks, equally pretty, equally busy),
			AIR				- dat alle andere kenmerken van beide vluchten gelijk zijn (even veilig, even comfortabel, even veel overstappen etc.),	- all other characteristics are equal for both flights (equally safe, equally comfortable, the same number of transfers, etc.),
				CYC		ACTIVE_ALTMODE_SP = EBIKE	- dat alle andere kenmerken van beide ritten gelijk zijn (even veilig, even mooi, even druk etc.),	- all other characteristics are equal for both trips (equally safe, equally pretty, equally busy, etc.),
CAR	PT		AIR	CYC	WLK		- dat alle omstandigheden (het weer, uw afspraken en bezigheden die dag) hetzelfde zijn als tijdens de reis die u heeft beschreven.	- all other circumstances (the weather, your appointments and activities that day) are the same as during the journey which you have described.
		NAV					- dat alle omstandigheden (het weer, het gedrag van de andere vaartuigen tijdens het wachten) hetzelfde zijn als tijdens de reis die u heeft beschreven.	- all other circumstances (the weather, the behaviour of other boats while waiting) are the same as during the journey which you have described.
				CYC		ACTIVE_ALTMODE_SP = EBIKE	- dat u op de elektrische fiets even hard moet trappen als op de gewone fiets.	- you have to pedal with an equal amount of force on the electric bike and the regular bike.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = (1 OR 2)	Eerder zei u dat uw organisatie **bereid** is om te betalen om uw reistijd te verkorten. Wilt u bij de volgende keuzes **de belangen van uw organisatie meewegen**.	You previously said that your organisation is **willing** to pay to reduce your travel time. Please **take the interests of your organisation into account** in the following choices.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = 3	Eerder zei u dat uw organisatie **niet bereid** is om te betalen om uw reistijd te verkorten. Wilt u ervan uitgaan dat u **in uw eigen tijd** reist en dat alle kosten **voor uw eigen rekening** komen.	You previously said that your organisation is **not willing** to pay to reduce your travel time. Please assume that you are travelling **in your own time** and that all costs are **for your own account**.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE &	Wilt u bij de volgende keuzes de **belangen van uw eigen bedrijf meewegen.**	Please **take the interests of your own company into account** in the following choices.

						PAID_EMPLOYMENT = 2		
CAR							Ter herinnering: U heeft uw reis van [ORIG] naar [DEST] beschreven. Deze reis duurde [BASETIME] en kostte [BASECOST] euro.	
	PT						Ter herinnering: U heeft uw reis met de [PTVEHIC] van [ORIG] naar [DEST] beschreven. U stapte op de [PTVEHIC] bij [DEP_STOP] en stapte weer uit de [PTVEHIC] bij [ARR_STOP]. Tijdens uw reis maakte u [NTRANSFERS] overstappen van [PTVEHIC] op [PTVEHIC]. De reis van deur tot deur duurde [BASETIME] en kostte [BASECOST] euro.	
			AIR				Ter herinnering: U heeft uw vliegreis van [ORIG] naar [DEST] beschreven. Deze enkele reis duurde [BASETIME] en kostte [BASECOST] euro.	
				CYC			Ter herinnering: U heeft uw reis met de fiets van [ORIG] naar [DEST] beschreven. Deze reis duurde [BASETIME]. De omstandigheden waren als volgt: - Neerslag: [PRECIPATION] - Wind: [WIND] - Temperatuur: [TEMPERATURE] - Hoeveelheid licht: [BRIGHTNESS]	
					WLK		Ter herinnering: U heeft uw reis te voet van [ORIG] naar [DEST] beschreven. Deze reis duurde [BASETIME]. De omstandigheden waren als volgt: - Neerslag: [PRECIPATION] - Temperatuur: [TEMPERATURE] - Hoeveelheid licht: [BRIGHTNESS]	

Table 85 – Instructions during SP1A/B/C

Mode filter						Additional filter	Text Dutch	Text English
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT != 2 & DECISION_BY_EMPLOYER < 3	Weeg de belangen van uw organisatie mee.	Take the interests of your organisation into account.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT != 2 & DECISION_BY_EMPLOYER = 3	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that you are travelling in your own time. Assume that all costs are for your own account.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT = 2	Weeg de belangen van uw eigen bedrijf mee.	Take the interests of your own company into account.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = TRUE	Neem aan dat u in uw eigen tijd reist.	Assume that you are travelling in your own time.
CAR	PT		AIR	CYC	WLK	(PURPOSE != BUSINESS & EMPPAY != 4) (respondent does not receive travel cost reimbursement) OR	Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that all costs are for your own account.

						(PURPOSE = BUSINESS & HENSHER = TRUE)		
CAR	PT			CYC			Neem aan dat beide ritten mogelijk zijn (ook als ze onrealistisch lijken).	
			AIR				Neem aan dat beide vluchten mogelijk zijn (ook als ze onrealistisch lijken).	
		NAV					Neem aan dat beide routes mogelijk zijn (ook als ze onrealistisch lijken).	
					WLK		Neem aan dat beide verplaatsingen mogelijk zijn (ook als ze onrealistisch lijken).	
CAR							Reistijdverschillen zijn het gevolg van andere routes en meer of minder congestie, niet van harder of minder hard rijden.	Travel time differences are the consequence of shorter routes and congestion, not of faster driving.
				CYC			Reistijdverschillen zijn het gevolg van andere routes, niet van harder of minder hard trappen.	Travel time differences are the consequence of different routes, not of pedaling with more force.
					WLK		Reistijdverschillen zijn het gevolg van andere routes, niet van harder of minder hard lopen.	Travel time differences are the consequence of different routes, not of walking faster.
				CYC		ACTIVE_ALTMODE_SP = EBIKE	U moet op de elektrische fiets even hard trappen als op de gewone fiets.	You have to pedal with an equal amount of force on the electric bike and the regular bike.

Table 86 – Instructions before SP2A/B/C

Mode filter						Additional filter	Text Dutch	Text English
CAR	PT			CYC			We gaan zo dadelijk weer steeds twee verschillende ritten voorleggen.	We are going to present two different trips repeatedly again.
		NAV					We gaan zo dadelijk weer steeds twee verschillende routes voorleggen.	We are going to present two different routes repeatedly again.
			AIR				We gaan zo dadelijk weer steeds twee verschillende vluchten voorleggen.	We are going to present two different flights repeatedly again.
					WLK		We gaan zo dadelijk weer steeds twee verplaatsingen presenteren. Ditmaal zijn beide verplaatsingen te voet.	We are going to present two different trips repeatedly again. This time both are walking trips.
				CYC		UsesEBIKE = false	Stelt u zich hierbij voor dat u deze ritten op uw eigen fiets aflegt.	Imagine that you make these trips on your own bicycle.
				CYC		UsesEBIKE = true	Stelt u zich hierbij voor dat u deze ritten op uw eigen elektrische fiets aflegt.	Imagine that you make these trips on your own electric bicycle.
CAR	PT		AIR				We voegen nu toe dat de reistijden **onzeker** zijn.	We add that the travel times are **uncertain**.
		NAV					We voegen nu toe dat de wachttijden **onzeker** zijn.	We add that the waiting times are **uncertain**.
				CYC			We voegen nu enkele reiskenmerken toe. Namelijk: het **type fietspad**, het **type verharding**, het **aantal voorbijrijdende auto's**, en hoe **mooi** de route is.	We add several trip characteristics, being the **cycling path** type, the **pavement** type, the **amount of bypassing cars**, and how **beautiful** the route is.
					WLK		We voegen nu enkele reiskenmerken toe. Namelijk: het **type voetpad**, **de breedte van het voetpad**, het **aantal voorbijrijdende auto's**, en hoe **mooi** de route is.	We add several trip characteristics, being the **walking path** type, the **path width**, the **amount of bypassing cars**, and how **beautiful** the route is.
CAR							Vertragingen kunnen ontstaan door bijvoorbeeld: - wegwerkzaamheden, - onverwachte drukte en files, - autopech, - een verhuisauto die aan het uitladen is.	Delays can occur for example due to: - road work, - unexpected traffic and congestion, - car trouble, - a moving van unloading.
	PT						Onverwachte vertragingen kunnen ontstaan door bijvoorbeeld: - onverwachte drukte, - onverwachte werkzaamheden. Maar een reistijd kan ook korter zijn dan verwacht omdat u bijvoorbeeld een bepaalde aansluiting net wel haalde.	Unexpected delays can occur for example due to: - unexpected crowding, - unexpected maintenance work. But the travel time can also be shorter, for example because you were unexpectedly in time for a transfer.
		NAV					Onverwachte vertragingen kunnen ontstaan door bijvoorbeeld onverwachte drukte voor een brug of een sluis, maar een wachttijd kan ook korter zijn dan vooraf gedacht.	Unexpected delays can occur due to, for example, unexpected crowding at a bridge or a lock, but the waiting time can also be shorter than expected on beforehand.
			AIR				Vertragingen kunnen ontstaan door bijvoorbeeld: - drukte op de luchthaven van vertrek, - drukte op de luchthaven van uw bestemming (waardoor vliegtuigen later landen), - het missen van een overstap, - slecht weer.	Delays can occur for example due to: - crowding at the airport of departure, - crowding at the airport of arrival (which causes planes to land later), - missing a connecting flight, - bad weather.
CAR	PT						We geven deze onzekerheid weer met 5 mogelijke **reistijden** voor dezelfde rit.	We present this uncertainty by means of 5 possible travel times for the same trip.
		NAV					We geven deze onzekerheid weer met 5 mogelijke **wachttijden** voor dezelfde route.	We present this uncertainty by means of 5 possible waiting times for the same route.
			AIR				We geven deze onzekerheid weer met 5 mogelijke **reistijden** voor dezelfde vlucht.	We present this uncertainty by means of 5 possible travel times for the same flight.
							VOORBEELD KEUZESCHERM	EXAMPLE CHOICE SCREEN

Table 87 – Instructions during SP2A/B/C

Mode filter						Additional filter	Text Dutch	Text English
CAR	PT		AIR			PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = (1 OR 2)	Weeg de belangen van uw organisatie mee.	Take the interests of your organisation into account.
CAR	PT		AIR			PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = 3	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that you are travelling in your own time. Assume that all costs are for your own account.
CAR	PT		AIR	CYC	WLK	PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT = 2	Weeg de belangen van uw eigen bedrijf mee.	Take the interests of your own company into account.
CAR	PT		AIR			PURPOSE = BUSINESS & HENSHER = TRUE	Neem aan dat u in uw eigen tijd reist.	Assume that you are travelling in your own time.
CAR	PT		AIR			(PURPOSE != BUSINESS & EMPPAY != 4) (respondent does not receive travel cost reimbursement) OR (PURPOSE = BUSINESS & HENSHER = TRUE)	Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that all costs are for your own account.
CAR							Reistijdverschillen zijn het gevolg van kortere routes en congestie, niet van harder gas geven.	Travel time differences are the consequence of shorter routes and congestion, not of faster acceleration.
				CYC			Reistijdverschillen zijn het gevolg van kortere routes, niet van harder trappen.	Travel time differences are the consequence of shorter routes, not of pedaling with more power.
					WLK		Reistijdverschillen zijn het gevolg van kortere routes, niet van sneller wandelen.	Travel time differences are the consequence of shorter routes, not of walking faster.

Table 88 – Instructions before SP3A/4A

Mode filter						Additional filter	Text Dutch	Text English
	PT						We gaan zo dadelijk weer steeds twee verschillende ritten voorleggen.	We are going to present two different trips repeatedly again.
	PT					DoSP3 = "true"	We geven nu ook aan waar de totale reistijd uit bestaat, namelijk: • de reistijd in de [PTVEHIC[40]] zelf, • de reistijd van en naar de [PTVEHIC], • en de totale wacht- en overstaptijd bij de [PTVEHIC]. Daarnaast voegen we het aantal overstappen van [PTVEHIC] naar [PTVEHIC] toe. Bijvoorbeeld:	
	PT					DoSP4 = "true"	We voegen nu enkele reiskenmerken toe, namelijk: • de drukte in de [PTVEHIC], • of u kunt zitten of moet staan in de [PTVEHIC], • en hoe vaak er een [PTVEHIC] rijdt per uur. Daarnaast tonen we nu alleen de reistijd in de [PTVEHIC] zelf, dus niet meer de reistijd van deur tot deur. Bijvoorbeeld:	
							VOORBEELD KEUZESCHERM	EXAMPLE CHOICE SCREEN
	PT					DoSP4 = "true"	Neemt u hierbij aan dat de drukte in de [PTVEHIC] gelijk blijft gedurende de rit.	

[40] PTVEHIC is a string variable with the main public transport mode used in the reference trip.

Table 89 – Instructions during SP3A/4A

Mode filter						Additional filter	Text Dutch	Text English
	PT					PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = (1 OR 2)	Weeg de belangen van uw organisatie mee.	Take the interests of your organisation into account.
	PT					PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = 3	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that you are travelling in your own time. Assume that all costs are for your own account.
	PT					PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT = 2	Weeg de belangen van uw eigen bedrijf mee.	Take the interests of your own company into account.
	PT					PURPOSE = BUSINESS & HENSHER = TRUE	Neem aan dat u in uw eigen tijd reist.	Assume that you are travelling in your own time.
	PT					(PURPOSE != BUSINESS & EMPPAY != 4) (respondent does not receive travel cost reimbursement) OR (PURPOSE = BUSINESS & HENSHER = TRUE)	Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that all costs are for your own account.
	PT					DoSP4 = “true”	De drukte in de [PTVEHIC] is constant gedurende de rit.	

Table 90 – Instructions before SP5A/6A

tmp_AIR_ACCESS_MODE = auto / trein / taxi, afhankelijk van [AIR_ACCESS_MODE], idem voor tmp_AIR_EGRESS_MODE

Mode filter						Additional filter	Text Dutch	
						DoSP5A = “true”	In het volgende deel gaat het over uw rit **naar** de luchthaven. Dus uw rit van **vertrekadres** naar **[ORIG]** met de **[tmp_AIR_ACCESS_MODE].**	
						DoSP6A = “true”	In het volgende deel gaat het over uw rit **vanaf** de luchthaven. Dus uw rit van **[DEST]** naar uw **eindbestemming** met de **[tmp_AIR_EGRESS_MODE].**	
PAGE BREAK								
			AIR			DoSP5A = “true”	We gaan zo dadelijk steeds twee **[tmp_AIR_ACCESS_MODE]-**ritten presenteren, waarin de vertrektijd, de reistijd en de reiskosten veranderd zijn. De **verwachte aankomsttijd op de luchthaven** is de tijd waarop u bij de incheckbalie of de bagage-afgifte aankomt. U moet er bij deze keuzes vanuit gaan dat als u daar na **[UITERSTE_TIJDSTIP]** aankomt op de luchthaven, u **NIET MEER TOEGELATEN** wordt op de vlucht. De incheckbalie en bagage-afgifte zijn dan gesloten en er is niet meer voldoende tijd om de veiligheidscontrole en de douane te passeren. Als u teveel vertraging heeft tijdens uw reis naar de luchthaven, dan mist u zeker uw vlucht. Bijvoorbeeld:	
			AIR			DoSP6A = “true”	We gaan zo dadelijk steeds twee **[tmp_AIR_EGRESS_MODE]-**ritten presenteren, waarin de reistijd en kosten veranderd zijn. Bijvoorbeeld:	
							VOORBEELD KEUZESCHERM	

Table 91 – Instructions during SP5A/6A

Mode filter						Additional filter	Text Dutch	
			AIR			PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = (1 OR 2)	Weeg de belangen van uw organisatie mee.	Take the interests of your organisation into account.
			AIR			PURPOSE = BUSINESS & HENSHER = FALSE & DECISION_BY_EMPLOYER = 3	Neem aan dat u in uw eigen tijd reist. Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that you are travelling in your own time. Assume that all costs are for your own account.
			AIR			PURPOSE = BUSINESS & HENSHER = FALSE & PAID_EMPLOYMENT = 2	Weeg de belangen van uw eigen bedrijf mee.	Take the interests of your own company into account.
			AIR			PURPOSE = BUSINESS & HENSHER = TRUE	Neem aan dat u in uw eigen tijd reist.	Assume that you are travelling in your own time.
			AIR			(PURPOSE != BUSINESS & EMPPAY != 4) (respondent does not receive travel cost reimbursement) OR (PURPOSE = BUSINESS & HENSHER = TRUE)	Neem aan dat alle kosten voor uw eigen rekening komen.	Assume that all costs are for your own account.

Appendix D: Comparing VTTs from different years

The nominal value of travel time for passenger travel[41] is expected to grow over time with

- inflation
- half of the growth of the wage rate (in real terms)

(Ministerie van Verkeer en Waterstaat en Centraal Planbureau, 2004).

Therefore, when the VTT from the 2009/2011 study (or from earlier studies) is compared to the results from the current 2022 study, the nominal values are expected to differ by these two factors. To determine the size of this (expected) difference, the following calculations should be made (see Table 92 for the actual values). ROW numbers in the text below refer to the lines in this table.

- Find the consumer price index (CBS, table “Consumentenprijzen; prijsindex 2015=100”) (ROW 1)
- Convert to a different reference year that is easier for interpretation (e.g. 1997=100) (ROW 2)
- Find the change of the nominal wage rate (this rate is published yearly by CPB in their “Centraal Economisch Plan”, variable “Loonvoet bedrijven” in table “Prijzen en lonen”). (ROW 13)
- Create a wage rate index with the same reference year as in step 2. (ROW 11)
- Convert the index for the nominal wage rate to the index for the real wage rate using the consumer price index (ROW 21)

  index real wage rate = 100 · index nominal wage rate / consumer price index

- Calculate the index for 50% of the development of the real wage rate (ROW 31)

  index 50% real wage rate = 100 + 50% · (index real wage rate – 100)

- Calculate the VTT index (ROW 41)

  VTT index = 100 · (consumer price index / 100) · (index 50% real wage rate / 100)

[41] The same growth is expected for freight transport by road.

Table 92 – Calculations for comparing VTTs for passenger travel (and freight transport by road) from different years

		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	**Consumer Price Index** (2015=100)	70.40	71.78	73.32	75.06	78.17	80.74	82.43	83.48	84.88	85.82	87.20	89.37	90.44	91.59	93.73	96.04	98.44	99.40	100.00	100.32	101.70	103.44	106.16	107.51	110.39	121.43
2	**Consumer Price Index** (1997=100)	100.00	101.96	104.15	106.62	111.04	114.69	117.09	118.58	120.57	121.90	123.86	126.95	128.47	130.10	133.14	136.42	139.83	141.19	142.05	142.50	144.46	146.93	150.80	152.71	156.80	172.49
3	Change (index points)		1.96	2.19	2.47	4.42	3.65	2.40	1.49	1.99	1.34	1.96	3.08	1.52	1.63	3.04	3.28	3.41	1.36	0.85	0.45	1.96	2.47	3.86	1.92	4.09	15.68
4	Change (percentage)		1.96%	2.15%	2.37%	4.14%	3.29%	2.09%	1.27%	1.68%	1.11%	1.61%	2.49%	1.20%	1.27%	2.34%	2.46%	2.50%	0.98%	0.60%	0.32%	1.38%	1.71%	2.63%	1.27%	2.68%	10.00%
11	**Wage rate index** (1997 = 100)	100.00	104.00	107.95	113.46	119.58	125.68	130.46	132.02	135.06	137.76	142.58	142.58	142.58	143.58	146.02	149.97	152.37	154.04	153.89	154.96	156.36	159.33	163.47	176.39	176.56	182.04
12	Change (index points)		4.00	3.95	5.51	6.13	6.10	4.78	1.57	3.04	2.70	4.82	0.00	0.00	1.00	2.44	3.94	2.40	1.68	-0.15	1.08	1.39	2.97	4.14	12.91	0.18	5.47
13	Change (percentage)		4.00%	3.80%	5.10%	5.40%	5.10%	3.80%	1.20%	2.30%	2.00%	3.50%	0.00%	0.00%	0.70%	1.70%	2.70%	1.60%	1.10%	-0.10%	0.70%	0.90%	1.90%	2.60%	7.90%	0.10%	3.10%
21	**Wage rate in real terms** (1997 = 100)	100.00	102.00	103.65	106.41	107.70	109.59	111.42	111.34	112.02	113.01	115.11	112.32	110.99	110.36	109.68	109.93	108.96	109.10	108.34	108.75	108.24	108.44	108.41	115.50	112.60	105.54
22	Change (index points)		2.00	1.65	2.76	1.28	1.89	1.83	-0.08	0.68	0.99	2.10	-2.80	-1.33	-0.63	-0.69	0.25	-0.96	0.13	-0.76	0.41	-0.51	0.20	-0.03	7.10	-2.90	-7.06
23	Change (percentage)		2.00%	1.62%	2.66%	1.21%	1.75%	1.67%	-0.07%	0.61%	0.88%	1.86%	-2.43%	-1.18%	-0.56%	-0.62%	0.23%	-0.88%	0.12%	-0.70%	0.38%	-0.47%	0.19%	-0.03%	6.55%	-2.51%	-6.27%
31	**Half of the development of real wage rate**	100.00	101.00	101.83	103.21	103.85	104.79	105.71	105.67	106.01	106.50	107.56	106.16	105.49	105.18	104.84	104.96	104.48	104.55	104.17	104.37	104.12	104.22	104.20	107.75	106.30	102.77
32	Change (index points)		1.00	0.83	1.38	0.64	0.94	0.92	-0.04	0.34	0.49	1.05	-1.40	-0.66	-0.31	-0.34	0.13	-0.48	0.07	-0.38	0.21	-0.26	0.10	-0.02	3.55	-1.45	-3.53
33	Change (percentage)		1.00%	0.82%	1.36%	0.62%	0.91%	0.87%	-0.04%	0.32%	0.47%	0.99%	-1.30%	-0.63%	-0.30%	-0.33%	0.12%	-0.46%	0.06%	-0.36%	0.20%	-0.24%	0.10%	-0.01%	3.40%	-1.35%	-3.32%
41	**VTT index** (1997 = 100)	100.00	102.98	106.05	110.04	115.31	120.19	123.77	125.30	127.81	129.83	133.22	134.77	135.52	136.84	139.58	143.19	146.10	147.62	147.97	148.73	150.41	153.13	157.13	164.55	166.68	177.26
42	Change (index points)		2.98	3.07	3.99	5.27	4.87	3.59	1.53	2.51	2.02	3.39	1.54	0.76	1.32	2.74	3.61	2.90	1.52	0.35	0.77	1.68	2.72	4.00	7.42	2.13	10.58
43	Change (percentage)		2.98	2.98	3.76	4.79	4.23	2.99	1.23	2.01	1.58	2.61	1.16	0.56	0.97	2.00	2.59	2.03	1.04	0.24	0.52	1.13	1.81	2.61	4.72	1.30	6.35
44	**VTT index** (2022 = 100)	56.41	58.10	59.83	62.08	65.05	67.80	69.83	70.69	72.11	73.24	75.16	76.03	76.45	77.20	78.74	80.78	82.42	83.28	83.47	83.91	84.85	86.39	88.65	92.83	94.03	100.00

Appendix E: Tables with detailed modelling results

In Sections E.1 – E.4 we present the estimated coefficients for the MNL models for SP1A, SP2A, and joint SP1A/2A. The last model in each table is the mixed logit estimation for the joint SP1A/2A model, which is identical to the one presented in Chapter 8. In that Chapter an explanation of the coefficient names can also be found. Sections E.5 contains the same information for SP1C/2C. Section E.6 contains the number of respondents per estimated parameter which shows how well founded each parameter is.

E.1 Car

	SP1A MNL		SP2A MNL		joint SP1A/2A MNL		joint SP1A/2A Mixed Logit	
Observations	15616		14880		30496		30496	
Final log (L)	-6575.7		-7190.7		-13807.0		-12572.1	
D.O.F.	27		31		33		36	
Rho²(0)	0.392		0.303		0.347		0.405	
vtt_ref	7.851	(15.9)	13.50	(17.1)	8.099	(22.2)		
vtt_m							2.030	(28.2)
vtt_sigma							0.7915	(21.9)
vttr_ref			1.788	(6.6)	0.9673	(5.9)		
vttr_m							-0.3474	(-2.2)
vttr_sigma							1.669	(29.6)
rho							0.4609	(17.7)
lmda_c_vtt	0.3643	(9.4)	0.2104	(5.5)	0.2885	(10.4)	0.3339	(7.0)
lmda_t_vtt	0.01051	(0.2)	0.05608	(1.1)	0.03013	(0.8)	0.04922	(0.8)
lmda_i_vtt	0.1511	(4.3)	0.1842	(5.2)	0.1695	(6.7)	0.1996	(4.0)
cf_noinc	-0.07273	(-1.2)	-0.04418	(-0.9)	-0.06106	(-1.6)	-0.03952	(-0.6)
cf_purp2	0.4710	(5.9)	0.6572	(7.1)	0.5349	(8.9)	0.4303	(4.5)
cf_wtp2_vt	2.893	(4.1)	1.181	(2.5)	1.987	(4.8)	2.927	(2.8)
cf_wtp4_vt	0.5637	(1.2)	0.6146	(1.3)	0.6386	(1.9)	0.7410	(1.0)
cf_purp3	-0.1302	(-2.7)	-0.09673	(-2.0)	-0.1211	(-3.6)	-0.1231	(-2.2)
cf_frq6	0.1846	(2.5)	-0.1014	(-1.9)	0.03065	(0.6)	0.1166	(1.0)
cf_gs_car3	0.2023	(2.6)	0.2294	(3.2)	0.2189	(4.0)	0.2323	(2.4)
cf_peak	0.1414	(3.0)	0.04657	(1.2)	0.08725	(2.8)	0.09261	(1.6)
cf_agecat3	-0.1719	(-4.8)	-0.1207	(-3.6)	-0.1511	(-6.1)	-0.1843	(-4.5)
cf_agecat4	-0.2987	(-5.9)	-0.2485	(-4.5)	-0.2795	(-7.2)	-0.3061	(-4.0)
cf_edu1	-0.2644	(-4.5)	-0.1508	(-2.8)	-0.2066	(-5.2)	-0.2327	(-3.9)
cf_edu2	-0.09291	(-2.2)	0.00363	(0.1)	-0.04967	(-1.7)	-0.09672	(-1.9)
cf_edu5	0.3517	(1.9)	0.2151	(1.2)	0.2760	(2.2)	0.2697	(1.1)
cf_hhsiz34	-0.1385	(-4.0)	-0.04360	(-1.3)	-0.08989	(-3.6)	-0.1164	(-2.7)
cf_zzp	0.1806	(2.7)	0.02944	(0.4)	0.1020	(2.1)	0.2350	(1.3)
cf_interce	0.2142	(3.7)	0.02852	(0.7)	0.1168	(3.2)	0.1555	(2.5)
cf_rrpurp2			-0.4071	(-2.0)	-0.2917	(-1.4)	-0.2252	(-2.5)
cf_rrpurp3			0.3051	(1.3)	0.4743	(1.8)	0.2667	(1.3)
cf_sp2					0.6594	(13.8)	0.5410	(12.1)
mu	-0.8412	(-23.0)	-0.6113	(-19.0)	-0.8537	(-28.6)	-1.294	(-18.4)
sc_sp2					0.6696	(26.9)	0.6523	(19.9)
sc_cstsame			2.472	(21.0)	2.523	(20.4)	3.790	(13.5)
lmda_c_mu	-0.2169	(-4.8)	-0.2156	(-4.6)	-0.2244	(-7.0)	-0.2365	(-4.7)
lmda_t_mu	-0.9036	(-15.1)	-0.9187	(-14.0)	-0.9171	(-21.3)	-0.8851	(-13.7)
cf_busi_mu	-0.3944	(-10.2)	-0.4668	(-11.9)	-0.4173	(-15.2)	-0.4678	(-11.5)
cf_wtp2_mu	0.4121	(2.3)	0.3756	(2.6)	0.4721	(3.9)	0.3433	(1.9)
cf_wtp4_mu	0.2786	(1.2)	0.2491	(1.6)	0.2892	(2.1)	0.1215	(0.7)
cf_othr_mu	0.2111	(3.6)	0.1030	(1.5)	0.1846	(4.2)	0.1046	(1.6)

E.2 Train

	SP1A MNL		SP2A MNL		joint SP1A/2A MNL		joint SP1A/2A Mixed Logit	
Observations	10104		6600		16704		16704	
Final log (L)	-3926.5		-3134.9		-7082.4		-6482.5	
D.O.F.	23		27		29		32	
Rho²(0)	0.439		0.315		0.388		0.440	
vtt_ref	9.998	(18.6)	15.73	(13.9)	9.839	(23.2)		
vtt_m							2.254	(8.5)
vtt_sigma							0.6200	(8.5)
vttr_ref			1.975	(4.9)	1.215	(4.8)		
vttr_m							-0.1351	(-0.1)
vttr_sigma							1.694	(4.7)
rho							0.1739	(0.7)
lmda_c_vtt	0.3048	(7.5)	0.1648	(3.8)	0.2586	(8.4)	0.3142	(6.4)
lmda_t_vtt	-0.03594	(-0.6)	0.00472	(0.1)	-0.02331	(-0.5)	-0.01910	(-0.3)
lmda_i_vtt	0.07289	(2.3)	0.1328	(4.1)	0.09568	(4.1)	0.1094	(3.5)
cf_noinc	-0.09025	(-1.4)	-0.07221	(-1.2)	-0.07447	(-1.6)	-0.04342	(-0.6)
cf_purp2	0.2672	(2.8)	0.2648	(2.3)	0.2464	(3.4)	0.1448	(0.7)
cf_wtp2_vt	3.915	(2.1)	2.933	(1.6)	4.157	(2.6)	8.257	(0.9)
cf_wtp4_vt	2.663	(1.2)	1.207	(1.0)	2.450	(1.6)	3.468	(0.6)
cf_purp3	-0.1403	(-3.3)	-0.1815	(-3.6)	-0.1558	(-5.0)	-0.1814	(-2.8)
cf_frq1	-0.2386	(-3.4)	-0.04981	(-0.6)	-0.1665	(-3.1)	-0.2263	(-2.0)
cf_frq234	-0.1525	(-3.3)	-0.04687	(-0.7)	-0.1100	(-2.9)	-0.1509	(-1.0)
cf_agect34	-0.1206	(-2.9)	-0.1375	(-3.0)	-0.1282	(-4.1)	-0.1110	(-1.0)
cf_wrksit2	-0.3319	(-3.4)	0.03747	(0.4)	-0.2230	(-3.1)	-0.2578	(-2.7)
cf_wrksit3	-0.2499	(-5.1)	-0.1456	(-2.6)	-0.2113	(-5.6)	-0.2443	(-2.8)
cf_wrksit5	-0.4521	(-1.7)	-0.4518	(-2.4)	-0.4491	(-2.6)	-0.2396	(-1.1)
cf_zzp	-0.3202	(-3.2)	-0.1359	(-1.5)	-0.2557	(-3.7)	-0.2503	(-2.9)
cf_rrpurp2			-0.5151	(-1.4)	-0.5265	(-1.5)	-0.6663	(-1.2)
cf_rrpurp3			-0.2543	(-0.9)	-0.2160	(-0.8)	-0.1485	(-0.2)
cf_sp2					0.6072	(10.6)	0.4998	(7.9)
mu	-1.088	(-21.5)	-0.6819	(-14.2)	-1.088	(-24.9)	-1.585	(-17.6)
sc_sp2					0.6244	(19.4)	0.6016	(12.5)
sc_cstsame			1.954	(14.8)	1.994	(14.4)	2.785	(7.7)
lmda_c_mu	-0.2105	(-4.2)	-0.2147	(-3.7)	-0.2192	(-5.9)	-0.2721	(-5.4)
lmda_t_mu	-0.8147	(-10.9)	-0.7186	(-7.7)	-0.7898	(-13.8)	-0.7302	(-8.6)
cf_busi_mu	-0.3580	(-6.2)	-0.4494	(-6.7)	-0.3916	(-9.0)	-0.3293	(-3.4)
cf_wtp2_mu	0.7672	(2.5)	0.1960	(0.8)	0.5634	(2.8)	0.6849	(1.2)
cf_wtp4_mu	0.3200	(0.9)	-1.142	(-2.1)	-0.2039	(-0.7)	-0.1127	(-0.3)
cf_othr_mu	0.1560	(2.2)	0.1332	(1.3)	0.1549	(2.8)	0.1346	(1.6)

E.3 Local public transport

	SP1A MNL		SP2A MNL		joint SP1A/2A MNL		joint SP1A/2A Mixed Logit	
Observations		9600		6000		15600		15600
Final log (L)		-3756.6		-2816.6		-6608.3		-6087.7
D.O.F.		25		29		31		34
Rho²(0)		0.435		0.323		0.389		0.437
vtt_ref	8.448	(15.7)	11.11	(13.3)	7.799	(18.9)		
vtt_m							1.918	(20.5)
vtt_sigma							0.7308	(11.9)
vttr_ref			1.756	(5.5)	1.130	(5.0)		
vttr_m							-0.8136	(-1.6)
vttr_sigma							2.263	(9.3)
rho							0.6347	(19.2)
lmda_c_vtt	0.4175	(9.5)	0.2446	(5.1)	0.3563	(10.4)	0.4374	(8.0)
lmda_t_vtt	0.00436	(0.1)	-0.09971	(-1.4)	-0.03257	(-0.6)	-0.08823	(-1.2)
lmda_i_vtt	0.1596	(3.7)	0.00879	(0.2)	0.1033	(3.2)	0.06687	(1.9)
cf_noinc	-0.1091	(-1.5)	0.05106	(0.7)	-0.05278	(-1.0)	0.03419	(0.3)
cf_purp2	0.3247	(2.8)	0.6942	(4.1)	0.4241	(4.2)	0.3288	(2.8)
cf_wtp2_vt	5.584	(2.1)	2.247	(1.7)	4.118	(2.7)	5.757	(1.9)
cf_wtp4_vt	2.275	(1.1)	0.08570	(0.1)	1.379	(1.0)	0.9683	(1.0)
cf_purp3	0.04692	(0.7)	0.04719	(0.7)	0.03735	(0.7)	0.04103	(0.6)
cf_frq12	-0.1259	(-2.5)	-0.03555	(-0.6)	-0.09327	(-2.3)	-0.06192	(-1.0)
cf_peak	0.09407	(1.6)	0.01043	(0.2)	0.06568	(1.5)	0.1006	(1.5)
cf_agecat3	-0.1124	(-2.1)	0.00785	(0.1)	-0.08100	(-1.9)	-0.06739	(-0.8)
cf_agecat4	-0.3111	(-4.0)	-0.1602	(-2.0)	-0.2730	(-4.7)	-0.3250	(-4.3)
cf_edu12	-0.1904	(-3.8)	-0.1234	(-2.3)	-0.1644	(-4.3)	-0.2024	(-4.0)
cf_edu5	-0.3915	(-2.5)	-0.00472	(-0.0)	-0.2137	(-1.8)	-0.1786	(-0.8)
cf_hhsiz34	-0.1317	(-2.8)	-0.00354	(-0.1)	-0.09079	(-2.4)	-0.08410	(-1.7)
cf_wrksit2	-0.2595	(-3.3)	-0.08146	(-0.9)	-0.2049	(-3.3)	-0.2330	(-3.1)
cf_wrksit5	0.1813	(0.6)	-0.1076	(-0.6)	0.04844	(0.3)	-0.1328	(-0.7)
cf_rrpurp2			-0.5629	(-1.7)	-0.6476	(-1.9)	-0.05878	(-0.2)
cf_rrpurp3			-0.1711	(-0.7)	0.02170	(0.1)	-0.1287	(-0.9)
cf_sp2					0.6839	(9.0)	0.5342	(7.2)
mu	-1.083	(-22.0)	-0.8021	(-14.4)	-1.108	(-25.0)	-1.519	(-16.0)
sc_sp2					0.6299	(16.8)	0.6250	(12.4)
sc_cstsame			2.344	(12.9)	2.528	(12.1)	3.565	(7.5)
lmda_c_mu	-0.2749	(-5.3)	-0.2217	(-4.0)	-0.2691	(-7.1)	-0.2596	(-4.0)
lmda_t_mu	-0.7528	(-10.3)	-0.7107	(-8.5)	-0.7547	(-13.9)	-0.7215	(-7.1)
cf_busi_mu	-0.3780	(-5.5)	-0.4971	(-6.9)	-0.4285	(-8.7)	-0.4017	(-5.2)
cf_wtp2_mu	0.4632	(1.1)	0.3114	(1.2)	0.3509	(1.5)	0.5006	(1.4)
cf_wtp4_mu	-0.1531	(-0.3)	-2.535	(-2.0)	-0.5276	(-0.9)	-1.213	(-0.8)
cf_othr_mu	0.01842	(0.3)	-0.1492	(-1.9)	-0.02938	(-0.6)	0.06529	(0.8)

E.4 Air

	SP1A MNL		SP2A MNL		joint SP1A/2A MNL		joint SP1A/2A Mixed Logit	
Observations		10960		4912		15872		15872
Final log (L)		-3964.9		-2420.1		-6403.7		-5720.9
D.O.F.		22		25		27		30
Rho²(0)		0.478		0.289		0.418		0.480
vtt_ref	38.57	(18.4)	86.08	(11.3)	40.23	(21.0)		
vtt_m							3.837	(49.5)
vtt_sigma							0.6404	(21.4)
vttr_ref			15.21	(7.5)	7.302	(8.4)		
vttr_m							1.806	(12.9)
vttr_sigma							1.397	(22.6)
rho							0.4543	(7.7)
lmda_c_vtt	0.3971	(14.6)	0.4004	(8.0)	0.3912	(16.4)	0.4416	(12.5)
lmda_t_vtt	-0.1210	(-3.9)	-0.1777	(-2.9)	-0.1300	(-4.7)	-0.1124	(-2.8)
lmda_i_vtt	0.1462	(4.8)	0.1187	(2.1)	0.1361	(5.3)	0.1080	(1.9)
cf_noinc	-0.06917	(-1.3)	-0.01342	(-0.1)	-0.04797	(-1.0)	-0.04770	(-0.6)
cf_purp2	0.2595	(4.1)	0.2262	(2.0)	0.2597	(4.6)	0.1939	(2.3)
cf_wtp2_vt	2.486	(2.8)	3.369	(1.5)	2.509	(3.2)	3.742	(1.8)
cf_wtp4_vt	2.483	(1.8)	1.435	(0.7)	2.309	(2.0)	4.429	(1.4)
cf_gs_oth2	0.09983	(2.0)	-0.06190	(-1.0)	0.05929	(1.4)	0.00344	(0.0)
cf_agect23	0.09557	(2.3)	-0.03474	(-0.6)	0.06759	(2.0)	0.09879	(1.7)
cf_wrksit2	0.2611	(2.7)	0.06787	(0.5)	0.2108	(2.6)	0.1948	(1.7)
cf_wrksit3	-0.3280	(-5.9)	-0.3622	(-3.3)	-0.3404	(-6.8)	-0.3812	(-4.8)
cf_wrksit4	0.4377	(4.0)	0.05273	(0.4)	0.3283	(4.0)	0.3002	(2.7)
cf_wrksit5	0.3004	(2.0)	-0.1126	(-0.6)	0.1952	(1.6)	0.06284	(0.5)
cf_rrpurp2			0.1187	(0.5)	0.06739	(0.3)	0.05465	(0.3)
cf_sp2					0.7998	(12.0)	0.5560	(9.1)
mu	-0.04150	(-26.9)	-0.02314	(-13.8)	-0.03991	(-29.8)	-0.06633	(-18.4)
sc_sp2					0.6294	(17.4)	0.5957	(12.3)
sc_cstsame			2.236	(12.5)	2.226	(12.2)	2.720	(8.3)
lmda_c_mu	-0.3169	(-8.2)	-0.3849	(-6.2)	-0.3395	(-10.3)	-0.3498	(-7.0)
lmda_t_mu	-0.7860	(-17.4)	-0.7845	(-8.9)	-0.7844	(-19.8)	-0.7438	(-13.3)
lmda_i_mu	0.1552	(4.3)	0.05028	(0.8)	0.1299	(4.2)	0.1819	(3.5)
cf_noinc_m	-0.1673	(-2.7)	0.09966	(0.7)	-0.1033	(-1.8)	-0.1584	(-2.0)
cf_busi_mu	-0.4775	(-13.2)	-0.3383	(-4.2)	-0.4426	(-13.2)	-0.4980	(-10.1)
cf_wtp2_mu	0.09415	(0.8)	0.5812	(1.4)	0.1859	(1.6)	-0.05319	(-0.4)
cf_wtp4_mu	0.4531	(2.7)	0.3671	(0.6)	0.4843	(2.9)	0.1900	(0.8)

E.5 Recreational navigation

	SP1A MNL		SP2A MNL		joint SP1A/2A MNL		joint SP1A/2A Mixed Logit	
Observations	2040		1984		4024		4024	
Final log (L)	-913.0		-1086.2		-2002.1		-1519.0	
D.O.F.	8		9		11		11	
Rho²(0)	0.354		0.210		0.282		0.455	
vtt_ref	8.190	(11.3)	9.367	(10.8)	7.778	(14.9)		
vtt_m							2.024	(11.3)
vtt_sigma							0.8756	(14.5)
vttr_ref			-1.943	(-1.4)	-1.599	(-1.4)		
lmda_i_vtt	0.2033	(3.8)	0.09106	(1.9)	0.1454	(4.1)	0.1860	(1.8)
cf_noinc	-0.1773	(-2.6)	-0.2801	(-4.4)	-0.2278	(-4.9)	-0.2968	(-2.5)
cf_gs_car2	0.3350	(4.0)	0.2835	(3.5)	0.3086	(5.3)	0.5269	(2.4)
cf_gs_car3	0.3660	(3.3)	0.4360	(4.0)	0.3980	(5.1)	0.5681	(2.3)
cf_hhsize2	-0.1533	(-2.0)	-0.02676	(-0.3)	-0.09252	(-1.6)	-0.1575	(-1.0)
cf_hhsiz34	-0.2940	(-4.4)	-0.1902	(-2.4)	-0.2420	(-4.6)	-0.3513	(-2.7)
cf_sp2					0.2668	(5.2)	0.2620	(4.2)
mu	-0.5075	(-22.9)	-0.3713	(-18.4)	-0.5077	(-22.9)	-0.8070	(-15.3)
sc_sp2					0.7291	(14.4)	0.8313	(10.8)

E.6 Number of respondents per estimated parameter

The following table displays the number of respondents that contributed to the estimation of a parameter (before parameters were constrained or combined with parameters of neighbouring levels).

	CAR	TRAIN	BTM	AIR	CYCLE	WALK	RECR.NAV	Remarks
Observations	15616	10104	9600	10960	8256	5352	2400	
Number of resp.	1952	1263	1200	1370	1032	669	300	
Number of respondentes contributing to each coefficient (before combining/constraining)								
Reference value of travel time								
vtt_ref	1952	1263	1200	1370	1032	669	300	
Continuous interaction variables on vtt								
lmda_c_vtt	1952	1263	1200	1370	1032	669	300	Elasticity of ratio BaseCost/BaseCost0 with BaseCost0 = 300 EUR for air travel and 5 EUR for all other modes. Higher travel costs imply a higher vtt
lmda_t_vtt	1952	1263	1200	1370	1032	669	300	Elasticity of ratio BaseTime/BaseTime0
lmda_i_vtt	1722	1103	1006	1201	869	594	240	Elasticity of ratio Income/Income0
cf_noinc	230	160	194	169	163	75	60	Interaction factor for respondents with unknown income level.
Categorical trip interaction variables on vtt								
cf_purp1	773	587	502	-	423	207	-	Purpose = commute (reference level for all modes except air (for which no commute trips are observed))
cf_purp2	487	212	172	340	158	126	-	Purpose = business
cf_purp3	692	464	526	1030	451	336	300	Purpose = other (reference level for air)
cf_frq1 (land modes)	263	178	149	-	52	55	-	Frequency = one-time trip
cf_frq2 (land modes)	505	343	370	-	168	175	-	Frequency = once/several times per year
cf_frq3 (land modes)	357	246	268	-	218	199	-	Frequency = once/several times per month
cf_frq4 (land modes)	329	294	197	-	244	136	-	Frequency = 1-2 times per week
cf_frq5 (land modes)	301	160	161	-	247	73	-	Frequency = 3-4 times per week (reference level)
cf_frq6 (land modes)	197	42	55	-	103	31	-	Frequency = 5 or more times per week
cf_frq1 (air/nav)	-	-	-	800	-	-	110	Frequency = one-time trip (reference level)
cf_frq2 (air/nav)	-	-	-	307	-	-	39	Frequency = less than once per year

cf_frq3 (air/nav)	-	-	-	250	-	-	108	Frequency = once/several times per year
cf_frq4 (air/nav)	-	-	-	12	-	-	41	Frequency = once/several times per month
cf_frq5 (air/nav)	-	-	-	1	-	-	2	Frequency = once/several times per week
cf_gs_1	1399	1032	939	322	-	-	152	Group size = 1 person (reference level)
cf_gs_oth2	-	231	261	1048	-	-	-	Group size = 2 persons or more
cf_gs_2	389	-	-	-	-	-	98	Group size = 2 persons
cf_gs_car3	164	-	-	-	-	-	50	Group size = 3 persons or more
cf_offpeak	1151	701	707	-	605	460	300	Period of the day = off peak (reference)
cf_peak	801	562	493	-	427	209	-	Period of the day = peak. This means that the midpoint of the trip falls between 7:00 and 9:00 or between 16:00 and 18:00.
cf_dirctn1	857	612	550	844	508	295	0	Direction = outward trip
cf_dirctn2	679	449	374	195	355	168	0	Direction = return trip
cf_dirctn3	416	202	276	331	169	206	300	Direction = other (i.e. non-home based trip)
Categorical personal interaction variables on vtt								
cf_male	1206	574	481	695	505	278	191	Gender = male (reference level)
cf_female	746	689	719	675	527	391	109	Gender = female
cf_agecat1	499	545	492	425	283	178	35	Age = 16-35 (reference level)
cf_agecat2	647	333	266	434	262	187	79	Age = 36-50
cf_agecat3	631	288	296	416	333	199	116	Age = 51-65
cf_agecat4	175	97	146	95	154	105	70	Age = 66+
cf_edu1	209	115	187	112	113	63	30	Education level = LO/MAVO/VBO/VMBO/LBO
cf_edu2	517	166	228	241	185	143	73	Education level = MBO
cf_edu34	1211	968	774	1001	642	396	192	Education level = HAVO/VWO/HBO/WO (reference level)
cf_edu5	15	14	11	16	92	67	5	Education level = Other
cf_hhsiz12	973	572	559	677	535	352	191	Household size = 1 or 2 persons (reference level)
cf_hhsiz34	979	691	641	693	497	317	109	Household size = 3 or more persons
cf_wrksit1	1640	906	791	1131	734	473	201	Work situation = employed (reference level)
cf_wrksit2	115	68	122	73	80	102	25	Work situation = unemployed
cf_wrksit3	33	194	165	63	66	13	7	Work situation = student
cf_wrksit4	150	79	108	87	143	72	64	Work situation = retired
cf_wrksit5	14	16	14	16	9	9	3	Work situation = other
cf_nozzp	1779	1199	1153	1251	965	609	251	ZZP-type = no
cf_zzp	173	64	47	119	67	60	49	ZZP-type = yes (self-employed)
cf_panel	1493	1024	1006	1041	743	669	166	Recruitment type = panel (reference level)
cf_interce	459	239	194	329	289	0	134	Recruitment type = intercept
Scale factor								
mu	1952	1263	1200	1370	1032	669	300	
Continuous interaction variables on scale								
lmda_c_mu	1952	1263	1200	1370	1032	669	300	Elasticity of ratio BaseCost/BaseCost0
lmda_t_mu	1952	1263	1200	1370	1032	669	300	Elasticity of ratio BaseTime/BaseTime0
lmda_i_mu	1722	1103	1006	1201	869	594	240	Elasticity of ratio Income/Income0
cf_noinc_m	230	160	194	169	163	75	60	Interaction factor for respondents with unknown income level
Categorical interaction variables on scale								
cf_comm_mu	773	587	502	-	423	207	-	Purpose = commute (reference level for all modes except air)
cf_busi_mu	487	212	172	340	158	126	-	Purpose = business
cf_othr_mu	692	464	526	1030	451	336	300	Purpose = other (reference level for air)

Appendix F: Literature review on VTT in freight transport

F.1 Review of the international the literature on the VTTF[42]

De Jong (2008) is a review paper on VTTF that contains outcomes for different modes from different studies reported up to 2007. An update can be found in de Jong (2014). In the table below, we summarise the main findings of the 2008 and 2014 papers and add some new studies. Another overview of VTTF was given by Feo-Valero et al. (2011).

Not all the studies included in de Jong (2008, 2014) or in the tables below were specific VTTF studies; some focused on the valuation of several freight service attributes, others were designed for predicting future freight volumes. Several assumptions with regard to average shipment size, shipment value, transport cost and times had to be made and exchange rates and price index numbers were used to convert to 2010 Euros. The values should therefore be only regarded as indications of the outcomes of the studies quoted. Furthermore, unlike the tables in de Jong (2008), we now tried to group the empirical outcomes (which for some studies was a somewhat subjective task) into:

- outcomes for the cargo component of the VTTF (not including vehicle and staff time costs)
- outcomes for the transport service component (vehicles and staff) of the VTTF (not including the cargo component)
- outcomes for both components together.

Table 93 gives the outcomes for road transport. These VTTF refer to an average truck. In the Dutch VTTF studies the average load is 8 tonnes (taking into account empty transports).

De Jong (2008) found a group of studies that obtained road VTTF in the range between 30 and 50 Euro (of 2002), which in Euros of 2010 would be the range between 35 and 60 Euro. This range can be found in the first row in the bottom part of Table 93 for both components of the VTTF together. Some of the studies included here are the first Dutch VTTF study (de Jong al., 1992), the 1994/1995 UK VTTF study (Accent and HCG, 1999), Fowkes et al. (2001), the second national Dutch VTTF study (de Jong et al., 2004) and Hensher et al. (2005). The first Norwegian VTTF and VTTRF study (Halse et al., 2010) and the 2009-2013 passenger and VTTF and VTTRF study in The Netherlands (Significance et al., 2012b) also find values just within this range for the sum of both components. The road VTTF from Significance et al. (2013) falls clearly within the range from Western-European studies.

The first Norwegian study recommended using factor cost for the transport service component and model outcomes for the cargo component. Model results for the transport service component were also obtained, based on the carriers. These are about 85% of the transport costs of an hour, but the authors warn that the estimate from the carriers might contain elements of the cargo component of the shippers. In the latest Dutch VTTF survey, specific instructions were used to keep the cargo and transport service separate (see Section 2.3). Here the transport service component of the VTTF is about 65% of the transport costs per hour: the carriers do not expect that time savings can fully be converted to cost savings. In the first Norwegian study, the cargo component for road transport is 17% of the combined VTTF and in the Dutch study for road transport this is 16%. So the models estimated for road transport in both of these studies indicate that the joint VTTF is practically equal to or somewhat below the factor cost, after including the cargo component (which is not part of the factor cost) in the VTTF. The cargo component is a relative small value, which is confirmed by the other outcomes for this component from the first part of Table 93.

[42] This literature review was written in 2019 and was updated in 2020. It does not contain the 2022 results for the Netherlands that are discussed in Chapter 15.

Table 93 - Value of transport time in freight transport (VTTF) by road

Publication	Country	Data	Method	VTTF (in 2010 Euro per transport per hour)
The cargo component in the VTTF:				
De Jong (2008)	Various Scandinavian studies up to 2001	SP	Different discrete choice models	0-10
Danielis et al. (2005)	Italy	SP	Ordered probit	7
IRE and RAPP Trans (2005), Maggi and Rudel (2008)	Switzerland	SP	MNL	14
Fries et al. (2010)	Switzerland	SP	Mixed logit	4
Halse et al. (2010)	Norway	SP	MNL and mixed logit	Large truck (carrying on average 12 t): 9
De Jong et al. (2011)	Netherlands	RP (mode choice)	Aggregate logit	6
Johnson and de Jong (2010)	Sweden	RP (mode and shipment size choice)	MNL and mixed logit	24
Significance et al. (2013)	Netherlands	SP	MNL	6
Halse et al. (2018)	Norway	SP	MNL and mixed logit	12 (truck carrying 8 t)
The transport service component in the VTTF:				
Halse et al. (2010)	Norway	Cost data	Factor cost	Large truck (carrying on average 12 t): 72
De Jong et al. (2011)	Netherlands	Cost data	Factor cost	27
Significance et al. (2013)	Netherlands	SP	MNL	32
Both components in the VTTF:				
De Jong (2008)	Various countries	Mostly SP	Mostly MNL	35-60
Halse et al. (2010)	Norway	Cost data and SP	Factor cost and MNL and mixed logit	Large truck (carrying on average 12 t): 81 truck (carrying 8 t): 54
Significance et al. (2013)	Netherlands	SP	MNL	38

The second Norwegian study (Halse et al., 2018) focussed on shippers and obtained a range between 2 and 194 NOK per tonne per hour (between 0.15 and 15 euro of 2010), depending on the commodity type (e.g. the maximum is for fresh fish and the minimum for timber) with an average value of 20 NOK per tonne per hour for all modes (about 1.5 euro of 2010), which comes down to 160 NOK per truck of 8 ton (about 12 euro of 2010). We interpret these values as referring to the cargo component.

It makes sense to exclude the purely distance-dependent transport costs (e.g., energy costs) from the factor costs that are used to determine the VTTF. The impact of reductions in transport distances can then be incorporated in the CBA through distance-dependent cost savings.

For other modes than road transport, fewer values are available from the literature. Most other VTTFs refer to rail transport. Table 94 for rail (or combined) transport, again summarises de Jong (2008, 2014) and provides some new evidence. The outcomes in this table are expressed per tonne (for the Dutch studies 950 tonnes for a complete train was used for the average load).[43]

As for road transport, the cargo component appears to be the minor component in the rail VTTF. In Significance et al. (2013) the share of the cargo component in the short term total VTTF is about 27%.

[43] VTTF for transport by inland waterways, sea and air transport can be found in de Jong (2008) and Significance et al. (2012b).

Table 94 - Value of transport time in freight transport (VTTF) by rail

Publication	Country	Data	Method	VTTF (in 2010 Euro per tonne per hour)
The cargo component in the VTTF:				
Widlert and Bradley (1992)	Sweden	SP	MNL	0.04
Kurri et al. (2000)	Finland	SP	MNL	0.11
Beuthe and Bouffioux (2008)	Belgium	SP	MNL (on ranking data)	0.20
Johnson and de Jong (2011)	Sweden	RP (mode and shipment size choice)	MNL and mixed logit	0.1
Significance et al. (2013)	Netherlands	SP	MNL	0.3 for all 0.4 for container 0.2 for bulk train 0.5 for wagonload
CGSP (2013); applies to all modes, not just rail	France	SP	MNL	0.01 for freight with low added value (< 6000 euro/t): e.g. bulk/aggregates 0.20 for ordinary freight (6000-35000 euro/t): e.g. other rail, sea and river transport 0.60 for freight with high added value (> 35000 euro/t): e.g. combined, parcels, refrigerated, roro
BVU and TNS Infratest (2014); applies to all modes, not just rail	Germany	SP	Nested logit	0.73 median for all modes, depending on the commodity type 0.31 for sea container 1.18 for land container 0.02 for shipments 100+ t 1.01 for agri/food products 0.37 for stone and earth 0.75 for petroleum (products) 0.73 for chemicals and fertilisers 0.83 for metal (products) 1.51 for vehicles and machines 0.20 for other intermediate and final products
Fowkes (2006, 2015); applies to road and rail transport	UK	SP: LASP interview	Manual method and weighted regression	0.45 for all goods 0.18 for coal 0.05 for metals 0.05 for aggregates 0.54 for oil and chemicals 1.76 for automotive 0.14 for other bulks 0.90 for container 1.35 for finished goods 9.00 for express goods
Halse et al. (2018)	Norway	SP	MNL and mixed logit	1.50 for all goods (land-based modes), with large variation between commodities
The transport service component in the VTTF:				
Significance et al. (2013)	Netherlands	transport cost functions	MNL	2.4 for all goods 1.8 for container 1.4 for bulk train 4.8 for wagonload

Publication	Country	Data	Method	VTTF (in 2010 Euro per tonne per hour)
Both components in the VTTF:				
Fowkes et al. (1991)	UK	SP	MNL	0.10– 1.44
Vieira (1992)	USA	SP+RP	Ordered logit	0.77
de Jong (1992)	Netherlands	SP	MNL	0.96
de Jong et al. (2001)	France	SP+RP	MNL	0.30 – 1.31
De Jong et al. (2004)	Netherlands	SP	MNL	1.14
Halse et al. (2010); Halse and Killi (2013): GUNVOR study	Norway	SP	MNL	3.5
Halse and Killi (2012): PUSAM study	Norway	SP	MNL	1.7 for all goods 6.1 for general cargo 0.9 for palletised goods
Significance et al. (2013)	Netherlands	SP for short-run and transport cost functions for long run	MNL	Short-run: 1.2 for all goods 1.1 for containers 0.7 for bulk train 2.2 for wagonload Long-run: 2.7 for all goods 2.2 for container 1.6 for bulk train 5.3 for wagonload

In terms of numerical values for the VTTF, the picture that emerges from Table 94 is that in all studies, except the recent German study (BVU and TNS Infratest, 2014) and the recent Norwegian study (Halse et al., 2018), the value of the cargo component in the VTTF is rather low (between 0.04 and 0.45 euro/tonne/hour for all goods together, with a central value of about 0.2), relative to the values found for the sum of both components (say around 1-2 euro/tonne/hour). Large values for the cargo component of the VTTF are only found for specific high-value commodities (e.g. in the recommend values for France: CSGP, 2013; or for automotive, container, finished goods and especially express goods in the UK). As for road transport, the cargo component appears to be the minor component in the rail VTTF. The BVU and TNS Infratest study with its rather high values for the cargo component, is an outlier relative to the other studies. Maybe these high values are due to the fact that the German study did not differentiate between VTTF for road and rail transport (nor did the second Norwegian study), so that the common values for both modes might be pushed upwards by including road as well, where the cargo component, also within commodity types, is usually higher. This can be seen as a selection effect: shippers that have a preference for speed are more likely to select road transport which is commonly faster.

The range that we obtain in Table 94 for the cargo component and for the combined value of time is rather large. Apart from methodological differences between studies and in income levels between countries, this can be explained by variation between commodity types. The total VTTF for rail per tonne is clearly lower than for road which comes down to 4.75 euro per tonne for The Netherlands and 6.75 for Norway).

The Norwegian values are at the high end. The value of 0.9 for palletised goods in Norway refers to truckload shipments that are transported by rail in some cases when time is relatively unimportant. The 6.1 for general cargo on the other hand refers to less-than-truckload shipments. In many countries, rail transport would not be attractive for such shipments, but in Norway, the rail operator Cargonet acts as a consolidator of such goods. Transport of less-than-truckload shipments will be relatively expensive, also when carried out by rail (this partly explains the high VTTF), but will keep the inventory costs down.

A major difference between Norway and most other countries in Europe is that in Norway rail transport mostly concerns general cargo transported in containers and not so much bulk goods.

For The Netherlands (Significance et al., 2013), the variation between goods/types of train is mainly caused by differences in the transport cost per tonne (which are strongly related to differences in the average loads of the train types). In CBA for transport projects in The Netherlands, for the first year the value directly from the SP is used (denoted 'short-run' in the table), whereas after ten years, the long-run value is used (and for years in between linear interpolation). The distance-dependent costs for rail freight in The Netherlands are 16-18% of the total transport cost. Therefore, they are more or less equal to the cargo component of the VTTF (which in this study was 10% of the full transport cost for non-containers and 20% for containers). In other words, in The Netherlands the distance-based cost and the cargo component more or less cancel out and the VTTF in the long run is about equal to the full transport cost (time and distance dependent). Of course, this equivalence could just be a (temporary) coincidence, and in the short run we only use a fraction of the staff and vehicle cost in the VTTF.

F.2 Review of the international the literature on the VTTFR

Table 95 provides an overview of quantitative results for the VTTRF in freight (largely based on Batley et al., 2008; Significance et al., 2013 and De Jong, 2014). As discussed in the previous section, the reliability ratio RR (that uses VTTRF expressed as the standard deviation) is probably the most practical measure for including the VTTRF in freight transport models. However, only few studies using this measure have been carried out. Recently, some results (Fowkes, 2006; Halse et al., 2010; Significance et al., 2013; Halse et al., 2018) have become available that indicate that in freight transport the RR from the early and often preliminary studies (MVA, 1996; de Jong et al., 2009) may have been too high.

UK

In a study on the VTTF of road transport for the Department for Transport, Accent/HCG (1995) also studied the value of time, but also the value of the probability that the shipment will be delivered later than the agreed time or time interval. These results could only be used under the assumption that the size of the delay would not change. The outcomes on reliability were not included in the recommendations for CBA.

Fowkes et al. (2001) studied several formulations of reliability on SP data. They concluded that there are many complex and varied reasons why freight transport and logistics operators value a high level of journey time predictability.

Fowkes (2006) describes SP experiments carried out in 2003 and 2004 with basically the same setup as in Fowkes (2001), but now with a mode choice (road versus rail). Originally, Fowkes obtained a reliability ratio of 0.31 (Fowkes, 2006). Both of these investigations are not used in official CBA guidelines. Recently, Fowkes re-worked the calculations of the reliability ratio and obtained different (generally higher) values (Fowkes, 2015).

The Netherlands

The first national freight value of time study in The Netherlands was Hague Consulting Group (HCG) (1992). This SP-based study also included as one of the attributes the probability of delay. In the recommended values for the CBA however, only the VTTFs were adopted, not the reliability value (mainly because information from the forecasting models was missing).

Bogers and van Zuylen (2005) studied transport time variability from the viewpoint of the truck drivers. This was part of a PhD research at the Delft University of Technology; the outcomes were not implemented in official project assessments or transport models.

In 2003-2004, a study (RAND Europe et al., 2004) was carried out to update the first Dutch freight value of time study. Again, probability of delay was among the attributes. In a special follow-up study (reported in de Jong et al., 2009) the outcome was converted to a value for the standard deviation of transport time by mode, which became a provisionally recommended value for CBA.

The third national study on value of time and reliability for passenger and freight transport was described earlier in this Appendix.

Table 95 - Value of transport time variability in freight transport (VTTRF) (in 2010 Euro), by VTTRF measure

Publication	Country	Data	Method	Quantitative outcomes (+definition) : transport time or cost equivalent
VTTRF measure:				**Percentage not on time**
HCG, (1992)	Netherlands	SP survey among shippers and carriers	MNL	An increase in the percentage not on time by 10% (e.g. from 10% to 11%) is just as bad as 5-8% higher transport costs.
Accent and HCG, (1995)	UK	SP among shippers and carriers (road)	MNL	A 1% increase in the probability of delay of 30 or more minutes. Is equivalent to 0.5 – 2.1 Euro per transport.
Bruzelius, (2001), based on Transek, (1990, 1992)	Sweden	SP among shippers	MNL	For rail transport, a 1% increase in the frequency of delays is equivalent to 5-8 Euro per wagon; For road transport: 4-37 Euro per transport.
Bruzelius, (2001), based on INREGIA, (2001)	Sweden	SP among shippers	MNL	The value of the risk of delay is 7 Euro per pro mille per transport for road, 128 for rail and 30 for air transport.
De Jong et al. (2004) **Also used in de Jong et al. (2009)**	Netherlands	SP survey among shippers and carriers	MNL	A change of 10% in the percentage not on time (e.g. from 10% to 11%) is equivalent to 2 Euro per transport for road transport. When converted to reliability ratio: 1.24. Also values for rail, waterways, sea and air.
IRE and RAPP Trans (2005), Maggi and Rudel (2008)	Switzerland	SP among shippers	MNL	A 1% point increase (e.g. from 10 to 11%) in the percentage not on-time has a cost of 42 euro per shipment
Fries et al. (2010)	Switzerland	SP among shippers	Mixed logit	A 1% point increase (e.g. from 10 to 11%) in the percentage not on-time has a cost of 16 euro per shipment
BVU and TNS Infratest (2014)	Germany	SP survey among shippers and carriers	Nested logit	A 1% increase in the percentage on time reduces the cost by 0.1 – 1.4 euro per tonne per hour (depending on commodity type; median 0.5); 1-hour delay costs between 0.1 and 53.6 euro per tonne per hour Results per commodity type: see next table
VTTRF measure:				**Reliability ratio (with standard deviation)**
MVA (1996)	UK	Literature review		Reliability ratio for transport: 1.2
Halse et al. (2010)	Norway	SP (mainly shippers in road transport)	MNL	Reliability ratio for shippers using road transport: 1.2 Reliability ratio for carriers (road): 0 Overall reliability ratio for road: 0.1
Significance et al. (2013)	Netherlands	SP survey among shippers and carriers	MNL	Reliability ratio for shippers using road transport: 0.3-0.9 Reliability ratio for carriers (road): 0 Overall reliability ratio for road: 0.4 Reliability ratio for rail: 0.2 Also values for inland waterways, sea and air transport.
Fowkes (2006, 2015)	UK	SP (LASP interview) among shippers using or potentially using rail	Manual method and weighted regression	Overall reliability ratio 0.66 -1.40 for coal 0.41 – 1.33 for metals 1.22 – 2.12 for aggregates 1.51 – 2.00 for oil and chemicals 1.35 – 1.81 for automotive 1.53 – 2.35 for other bulks 0.94 – 1.56 for container 0.79 – 1.32 for finished goods 2.79 – 2.93 for express goods
Halse et al. (2018)	Norway	SP	MNL and mixed logit	Reliability ratio for shippers: 0.21 (implying an overall reliability ratio of around 0.05)
VTTRF measure:				**Schedule delay**
Small et al. (1999)	USA	SP survey among hauliers	MNL scheduling model	A reduction in the deviation from the agreed delivery time (schedule delay) by 1 hour is worth 450 Euro per transport
Fowkes et al. (2001)	UK	SP survey among shippers and carriers (road)	MNL	The value of the difference between the earliest arrival time and the departure time is on average 1.4 Euro per minute per transport (more or less the free-flow time); For the time within which 98% of the deliveries takes place minus the earliest arrival time, the value is 1.7 Euro (‘spread’); For deviations from the departure time (schedule delay) the value is 1.3 Euro.

Publication	Country	Data	Method	Quantitative outcomes (+definition) : transport time or cost equivalent
VTTRF measure:				**Other**
Bogers and van Zuylen, (2005)	Netherlands	SP among truck drivers and managers of shippers and carriers	MNL	Truck drivers value the unfavourable travel time twice as high as its objective (risk-neutral) worth. Managers of shippers and carriers did not have this relatively higher value for unfavourable travel times.
Hensher et al. (2005)	Australia	SP for tolled and toll-free roads	Mixed logit	VTTRF of 2.5 Euro per percentage point for transporters, 7.50 Euro for shippers. This is obtained when looking solely at the freight rate; when further incorporating all costs in the calculation, the VTTRF rises to 9.1 Euro. Giving an actual meaning to these values, the results would imply that, if a toll free route had a 91% probability of on-time delivery, with 97% for the tolled route, the VTTRF for transporters would be 15 Euro per trip.

Sweden
Bruzelius (2001) is an overview of studies on the value of time and reliablity in freight transport. It described two studies carried out in Sweden (and originally reported in Swedish): the 1990/1992 studies for rail and road by Transek and the 1999 study by Inregia and COWI. Both studies presented reliability as the probability of delay. The VTTF from these studies were used in the official recommendations for CBA in Sweden, but not the reliability values.

Norway
Halse et al. (2010) report the methods used and the outcomes of the Norwegian freight value of time study ('GUNVOR'). The SP design was partly adopted from de Jong et al. (2007), using a representation with five transport times per alternative that are all equally likely. The study produced values of reliability for shippers, for carriers the reliability values were not significant. Halse et al. (2012) is a follow-up study (PUSAM) that focuses on rail transport time and its reliability between railway stations. For practical CBA in rail freight transport in Norway, the outcomes of PUSAM are used now. The measure of unreliability here is the expected delay (size of the delay multiplied by its probability), which was chosen to be consistent with the tradition in Norwegian rail transport to measure reliability as delays. In the SP experiments this was presented by asking the respondents to compare a 100 reliable transport alternative against an alternative where some fraction (say 80%) of the transports arrive on schedule and the remaining fraction arrives with a specified delay (e.g. 20 minutes) relative to the agreed schedule. By multiplying the probability of delay times its size, the researchers can calculate the expected delay for each alternative, and this is the variable that was used in model estimation and for recommended values in rail transport.

The latest Norwegian VTTF and VTTRF study (Halse et al., 2018) only interviewed shippers (mainly shippers that contract out transport) and obtained a reliability ratio for all the goods of 0.21 for shippers, which translates to about 0.05 for the overall reliability ratio (also including the transport services component in the VTTF). There also was variation between commodity types in this ratio, but no logical pattern could be discerned in this, and the final recommendation was not to use the values by commodity, but the reliability ratio of 0.21 for shippers.

France
De Jong et al. (2001) carried out an SP study on attributes in modal choice in freight transport in the French region Nord-Pas-de-Calais. The project yielded values for the probability of delay, but these were not used further.

Australia
In Australia, Puckett (with Hensher, Rose and others) has developed SP methods and model specifications that allow for interaction between shippers and carriers. The SP attribute that they include on reliability is the probability of a delay (Pucket and Rose, 2009). These studies have been carried out by the University of Sydney and are not meant to derive values for official CBA or transport models.

Germany
The German Federal Ministry of Transport (BMVDI) commissioned BVU and TNS Infratest to develop a model that can be used to determine modal shift in freight transport as well as VTTF and VTTRF for the federal infrastructure planning 2015 (BVU und TNS Infratest, 2014). To this end, SP/RP interviews

were carried out with almost 500 senders and receivers of goods as well as carriers. The researchers decided not to use the standard deviation of transport time because firms often cannot understand this concept. (this however should not be a problem, see Tseng et al. (2009), Significance et al. (2007, 2013) and de Jong et al., (2014)). Therefore, they present transport time unreliability in the SP using two complementary attributes:

- Probability that there will be no delay (BVU and TNS Infratest call this ‘punctuality’);
- Size of the delay.

The same attributes are used in the model estimation. Models have been estimated for ten different commodity types (see Table 96).

Table 96 - Value of transport time variability (VTTFV) in freight transport (in 2010 Euro per tonne per hour) from BVU and TNS Infratest (2014), by commodity type (for all modes)

Commodity type	a 1% increase in the percentage on time reduces the cost by:	1 hour delay costs:
Sea container	0.36	1.92
Land container	0.33	2.64
Shipments 100+ t	0.10	0.08
Agri/food products	0.42	2.42
Stone and earth	0.16	0.91
Petroleum (products)	0.74	3.95
Chemicals and fertilisers	0.81	0.34
Metal (products)	0.50	2.09
Vehicles and machines	1.38	53.61
Other intermediate and final products	0.90	3.58
Median	0.46	2.26

In Figure 22 the various results for the reliability ratio (using the standard deviation of travel time to the total VTTF) are compared. For road transport, the few available studies lend some support for an overall RR below 0.5. For rail, considerable variation in the overall RR between commodities has been found (Fowkes, 2006), but also considerable disagreement between the study of Significance et al. (2013) and Fowkes (2006). In the latter publication, all individual commodity types studied have an RR that is above that for all commodity types together of Significance et al. (2013). It is unclear what causes this discrepancy. The Dutch study (Significance et al., 2013) produces RRs that are at the lower end of the range from the available studies in Western Europe.

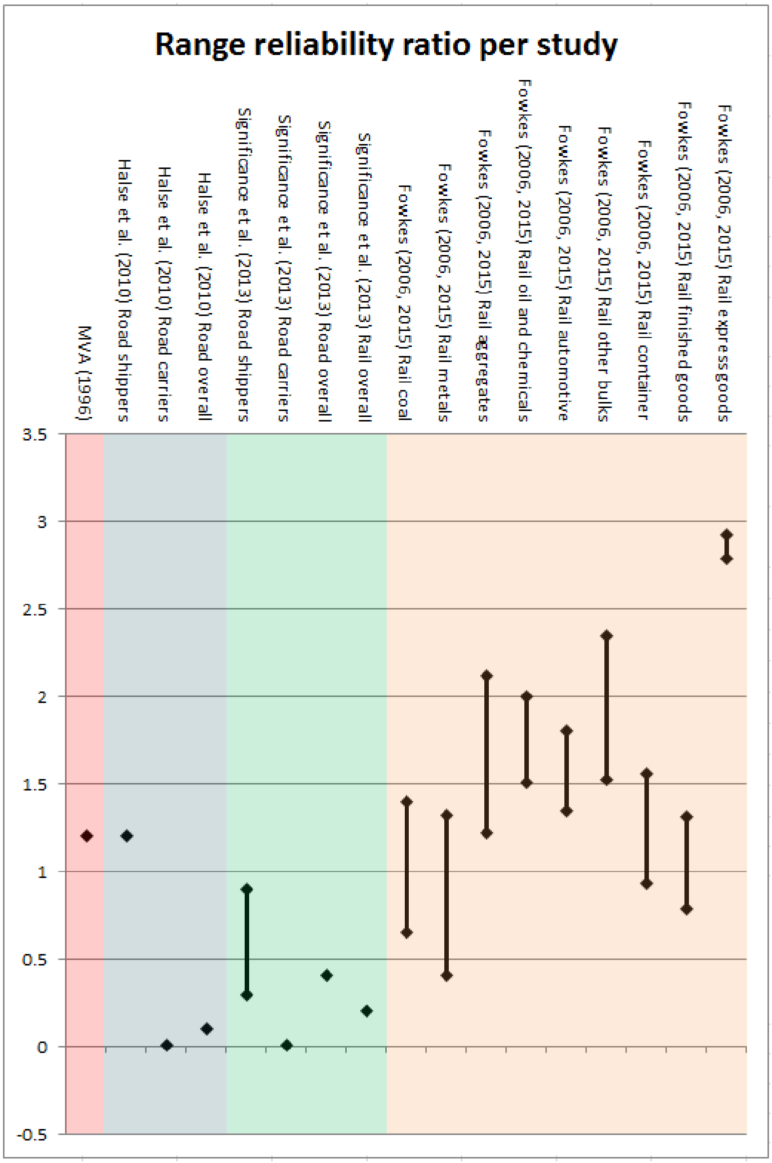


Figure 22 - Range reliability ratio per study

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