Ministry of Infrastructure and the Environment

The social value of shorter and more reliable travel times

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Contents

Summary

This publication presents the new social-economic values for changes in average travel times and in the reliability of travel times. These values can be applied to societal cost-benefit analyses of infrastructure projects. These are the first values of reliability which are based on empirical research. In addition, this is also the first time that the values for passenger air transport and recreational navigation were determined based on empirical research.

On behalf of the Directorate-General of the Ministry of Infrastructure and the Environment, KiM Netherlands Institute for Transport Policy Analysis has provided new social-economic values of travel times and the reliability of these travel times. These values are applied in the societal cost-benefit analyses conducted for infrastructure projects. KiM has determined values for the following transport modes:

- Passenger transport: car, bus, tram, metro, train, airplane, and recreational navigation;
- Freight transport: road, rail, inland waterways, sea, and air.

Relation to investment decisions

Societal cost-benefit analysis is an important instrument in investment decisions pertaining to transport infrastructure projects, such as railway line expansions, new highways, airport expansions or the widening of waterways. Important social benefits not only include shorter travel times for people and freight, but also a greater degree of reliability in these travel times. In order to use the social-economic value of these travel time savings and the increased reliability in a cost-benefit analysis, these values need to be expressed in monetary terms.

Reliability is defined as the extent to which travel times are certain, or as the variation around average travel times. For passenger transport, unexpected delays lead to costs resulting from the additional waiting times, stress levels among passengers, missed connections, missed appointments, and the negative impact on the efficiency of companies. For freight transport, the primary issue is the costs stemming from an inefficient use of transport personnel and materials, as well as missed opportunities pertaining to stock management, production and distribution systems. Predictable travel times are a vital prerequisite for organising logistical processes according to the *just-in-time* principle.

In addition to their application in cost-benefit analyses, values of travel time and reliability can also be used for calculating the costs of traffic jams, and for cost effectiveness analyses, which compare various policy measures and investments.

How are the values determined?

Stated-preference surveys are used, whereby the respondents are presented with situations in which the costs of a journey, the travel times and the travel time reliability vary. Based on the respondents' choices, it is possible to derive their trade-offs among travel times, travel time reliability and expenditures against one another.

Data collection for passenger travel and transport is conducted in two steps. In the first sample survey, the respondents were recruited from the largest online panel (PanelClix) in the Netherlands, which involves 240,000 participants and processing via an internet survey (number of respondents: 5,760). In the second sample survey, the respondents (1,430) were recruited in the same manner as for the previous research study; namely, at petrol stations along the motorways, parking garages, train stations, tram and bus stops, airports (Schiphol and Eindhoven), and marinas (recreational navigation). For freight transport, only *face-to-face* interviews were used, owing to the greater complexity of the survey questions (number of respondents: 812).

The latest relevant national and international scientific developments were processed in this research study. The *stated preference surveys* were compiled in collaboration with the Ministry and various sector organisations, including NS, ProRail, ANWB, EVO, Transport en Logistiek Nederland (Transport and Logistics Netherlands), *Centraal Bureau voor de Rijn- en Binnenvaart* (Central Bureau for Inland Shipping), Amsterdam Airport Schiphol and KLM airlines. In addition, a broad consultative group of international researchers routinely read and provided feedback on the draft texts and findings.

Why new values?

Values of travel time are periodically determined through the use of major empirical research studies conducted among passengers, carriers and shippers. In the time period between the two empirical research studies, the values were annually increased in line with inflation and wage developments. The most recent empirical research study for passenger transport was conducted in 1997. Today, more than 15 years later, the values of travel time for passenger transport were once again tested in practice and adjusted accordingly. An update was also performed for freight transport. The most recent empirical research study for freight transport was conducted in 2004.

In addition, for the first time, the values of travel time for aviation in this study were determined based on empirical research. Moreover, values of time for recreational navigation were also determined for the first time. The values for recreational navigation relate to waiting times at locks and bridges, which is not related to travel times. Travel time savings are irrelevant in this context, precisely because for recreational navigation the value is derived from the journey itself. Recreational navigation is an important user group of bridges and locks, and the benefits they derive from shorter waiting times can now be satisfactorily included in the cost-benefit analyses conducted for investments in these bridges and locks.

Finally, for the first time, the social-economic values for travel time reliability in this study were determined based on empirical research. In 2005, the social-economic values for improving travel time reliability were determined based on the findings of an international *expert meeting*, organized by the Dutch Ministry of Public Works, Transport and Water Management. At that time, the requirements for values of travel time reliability based on empirical research were formulated. That research has now been conducted and the research findings are described in this publication.

To date, when calculating the social-economic benefits of increased reliability of journey times in road works projects, a 25 percent mark-up of journey time benefits was applied. This was done because of a lack of sufficient information about the actual effects policy measures had on journey time reliability. This mark-up approach was meant to be temporary and replaced when information about the effects certain measures had on travel time reliability became available.

Main differences in travel time valuations

Travel behaviour changes over time. Consequently, differences between old and new values of travel time may arise, owing to, for example, an improved utilization of travel time by means of ICT (mobile phones, laptops or tablets). In addition, differences arise as a result of new scientific insights and developments that render changes in methodology necessary.

The new value of travel time for car travel is on average around 16 percent lower than the current value. The increasing use of mobile telephones during journeys could be one plausible explanation for car travel's lower valuation, since a part of the travel time can therefore be spent usefully, whereby an hour of travel time savings is valued lower. This is called 'journey time enrichment'.

Table S1: Differences between the currently used social-economic values and the new values of travel times.

Passenger transport	Difference	Freight transport	Difference
Car	-16%	**Road**	-16%
Train	+ 22%	**Rail**	-13%
Bus/ tram/metro	+ 2%	**Inland waterway, lock**	+ 7%
Airplane	+ 86%	**Sea, quay**	-8%
		Air	-7%

For trains, we note an increase in the value of travel time, but here travel time enrichment plays a smaller role than with cars, which is perhaps owing to the fact that it has always been possible to read work reports in the train, for example. For trains in particular the upwards effect between long and short journey distances can be clearly distinguished. In the previous study (1997), it was not yet possible to draw distinctions between longer and shorter journeys, but this is now possible. Longer travel distances have on average a higher value of travel time than shorter travel distances. This is partly due to the associated fatigue levels and lack of comfort, which are more prevalent the longer journeys last, and partly due to the fact that converting one hour of travel time into leisure time has more value if, owing to a longer journey time, people are left with less leisure time. Train passengers on average travel longer distances than people who travel by car, bus, tram or metro.

For the first time empirical values of time social-economic values for air travel have been established using a *stated preference survey*. The old, model-based values for air travel are unsuitable for making comparisons with valuations derived from this empirical study. The differences in freight transport were primarily due to a revised method.

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1 Research background and objectives

The Societal Cost-Benefit Analysis (SCBA) is an important instrument in investment decisions pertaining to transport infrastructure projects, such as railway line expansions, new highways, airport expansions or the widening of waterways. Important social benefits not only include shorter travel times for people and freight, but also a greater degree of reliability in these travel times. These benefits are always comprised of a 'financial value per unit' (P) multiplied by a 'quantity '(Q). If, for example, owing to the construction of a new road, a traffic bottleneck is resolved, whereby travelers save 'Q' hours per year in travel time, then the annual travel time benefits are expressed as 'P' X 'Q'. This research study is about the 'financial value per unit', focusing on the societal value of travel time and reliability.

Value of Time (abbreviated as 'VoT') expresses the social benefits derived from decreases in average travel times, or conversely the social-economic costs of increases in average travel times. Values of travel time are periodically determined by means of major empirical research studies conducted among passengers, carriers and shippers. In the time period between the two empirical research studies, the values were annually increased in line with inflation and wage developments. The most recent empirical research study for passenger transport was conducted in 1997 (Hague Consulting Group, 1998). Today, some 15 years later, the values of travel time for passenger transport were once again tested in practice and adjusted accordingly. An update was also performed for freight transport. The most recent empirical research study for freight transport was conducted in 2004 (Rand Europe et al.).

In addition to travel time savings, the reliability of travel times is an important benefit category in the SCBA. Reliability is important qualitative aspect of a journey, trip or transport. Reliability is defined as the extent to which travel times are certain, or as the variation around average travel times. When we speak of reliability of travel time, the most attention is focused on arriving late; however, arriving too early also generates extra costs, such as waiting at destinations. For passenger transport, unexpected delays lead to costs that result from additional waiting times (with a higher degree of disutility, stress among passengers, missed connections, missed appointments, and the negative impact on the efficiency of companies.

To reduce the likelihood of arriving too late, travellers often build in safety margins, thus deviating from their preferred arrival times (scheduling costs). For freight transport, unexpected delays lead to costs stemming from an inefficient use of transport personnel and materials, missed connections, waiting times, and missed opportunities pertaining to stock management, production and distribution systems. Predictable travel times are a key prerequisite for organising logistical processes according to the *just-in-time* principle.

Providing reliable travel times for passenger and freight transport is an important subject in the Structural Vision Infrastructure and Spatial Planning (*Structuurvisie Infrastructuur en Ruimte;* Ministry of Infrastructure and the Environment, 2012). Improving the reliability of travel times means to reduce unexpected delays. The *Value of Reliability* (abbreviated as 'VoR') expresses the social benefits that derive from reducing the dispersion (standard deviation) of travel time. In 2005, the social-economic values for improving travel time reliability were determined based on the findings of an international *expert meeting,* organized by the Dutch Ministry of Public Works, Transport and Water Management (Hamer et al., 2005; De Jong et al., 2009). At that time, the requirements for values of travel time reliability based on empirical research were formulated. That research has now been conducted and the research findings are described in this publication.

This research study provides new social-economic values for travel times and for the reliability of these travel times, which can be applied in the societal cost-benefit analyses conducted for infrastructure projects, according to the OEI (Overview Effects Infrastructure; see Ministry of Transport & Waterways and Ministry of Economic Affairs, 2000), and the CBAs for MIRT-studies (Ministry of Infrastructure and the Environment, 2012), for the following transport modalities:

- Passenger transport: car, bus, tram, metro, train, airplane, and recreational navigation;
- Freight transport: road, rail, inland waterways, sea, and air.

In addition to their application in cost-benefit analyses, values of travel time and reliability can also be used for calculating the costs of traffic jams, and for cost-effectiveness analyses, which compare various policy measures and investments.

Under the supervision of the KiM Netherlands Institute for Transport Policy Analysis, the research was conducted by a consortium comprised of: Significance, VU University Amsterdam, John Bates Services, TNO, NEA, TNS NIPO, and PanelClix. All technical and methodological details of the research are described in Significance et al. (2013). Below we discuss the starting points for the study (Chapter 2) and the new social-economic values for travel time and travel time reliability (Chapter 3). In conclusion, we compare the old and new social-economic values with each other (Chapter 4).

2 Starting points for updating social-economic values

In this chapter we detail the starting points used for updating the socio-economic values, namely:

- Average travel time and dispersion
- *Stated-preference* research
- No double counting
- Representative for all of the Netherlands
- *State-of-the-art*

Average travel time and dispersion

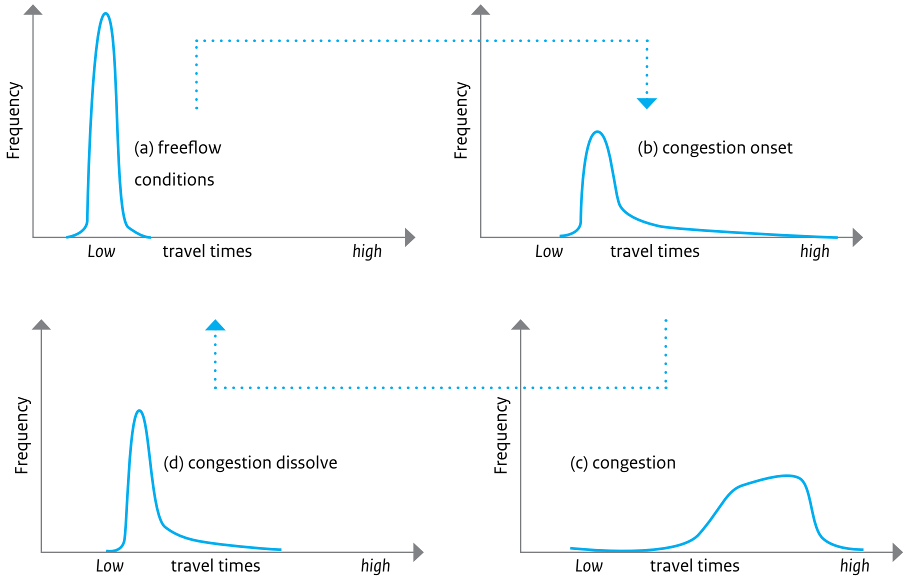
When we speak of travel time savings, at issue is a shorter average travel time. Reliability is defined as the extent to which travel times are certain, or as the variation around the average travel time. Expected delays are included in the average travel time.

Unexpected delays lead to variations around the average travel time and thus to a certain degree of unreliability. Unexpected delays can be caused by congestion and other factors, including inclement weather, accidents or incidents on the road, water or the (OV) public transportation network. We can distinguish two types of unexpected delays (Ritsema van Eck et al., 2004). The first type influences the daily (random) variation of travel times in journeys which are undertaken every day at the same time of day. The second type is irregular delays caused by incidents[1].

Van Lint (2004) has shown that four phases per day can be distinguished, in which the average travel times and variations around that average travel time clearly differ, namely: (a) *free flow* conditions, the early morning hours free of congestion, (b) *congestion onset*, in which the dispersion of travel time increases; there is also a so-called 'tail', during which travelers face major unexpected delays, (c) *congestion*, in which the majority of travelers face longer than average travel times and larger dispersions of travel time, and hence greater unreliability, and (d) *dissolving congestion*. These four phases and corresponding types of travel time distribution are represented in Figure 2.1.

[1] Incidents can cause extreme outliers in travel time if the transport network is not sufficiently robust. Robustness is defined as the degree to which extreme travel times can be prevented as a consequence of incidents. Robustness is a part of reliability.

Figure 2.1: The type of travel time distribution differs per time of day



Source: Van Lint (2004)

When planning a journey, one must not only consider the expected average travel time but also the variations in travel times around that average. The social-economic value of travel time pertains to the reduction in variations of travel times. In this study, reliability is measured in terms of the dispersion around the average travel time (standard deviation). This approach is based on a recommendation from an international expert meeting organized by the former Ministry of Transport, Public Works and Water Management (Hamer et al., 2005), a recommendation that was subsequently adopted by HEATCO[2] en de OECD[3].

Stated-preference research

In 1988, the former Ministry of Transport, Public Works and Water Management commissioned the first major empirical research study aimed determining the social-economic values for travel times. This research used *stated-preference* research, whereby the respondents were presented with various options in which the costs of a journey, travel times, and travel time reliability all varied, as based on the total expected travel time from door-to-door. From this it could be deduced how the respondents traded off their travel times, travel time reliability and expenditures against each other. In the current research study, the respondents were also presented with situations in which the costs, average travel times and dispersion around the average travel time varied.

In *stated-preference* research, the researcher has control over the variations in costs, travel times and dispersion of travel times that are presented to the respondents. Such control is impossible in *revealed-preference* research, in which researchers study the respondents' actual choice behavior in empirical situations[4].

In *stated-preference* models, the common assumption is that travelers, carriers and shippers strive to maximize their individual utility and rationally trade off travel time, reliability and costs, which was also the starting point of this research study.

[2] HEATCO: Harmonised European Approaches for Transport Costing and Project Assessment, http://heatco.ier.uni-stuttgart.de
[3] OECD-ITF (2010), *Improving Reliability on Surface Transport Networks*, Paris: OECD.
[4] An exception in which *revealed-preference* data serves as a good foundation is the choice between a reliable toll road and a free route where congestion is possible. For example on State Route 91 in California.

The *stated-preference* surveys were devised in collaboration with the various sector organisations, including NS, ProRail, ANWB, EVO, Transport en Logistiek Nederland (Transport and Logistics Netherlands), *Centraal Bureau voor de Rijn- en Binnenvaart* (Central Bureau for Inland Shipping), Amsterdam Airport Schiphol and KLM airlines. In addition, a broad consultative group of international researchers routinely read and provided feedback on the draft texts and findings.

No double counting

To prevent double counting of values for travel time and reliability, we presented each respondent with three *stated-preference* experiments; see Table 2.1. In the first experiment, the respondents were asked to weigh the travel time and costs against each other. These questions were the same as those in the *stated-preference* interviews conducted (for passengers) during the previous value studies conducted in 1988 and 1997. In the subsequent series of questions, the respondents were asked to weigh the travel time, travel costs and dispersion of travel times and arrival times against each other. By focusing on the arrival time, the value of travel time reliability was also studied based on the consequences this had for daily scheduling. See Significance et al. (2013) for examples of the questions included in all *stated-preference* experiments.

Table 2.1: The three *stated-preference* experiments for passenger travel and freight transport

	Experiment 1	Experiment 2a	Experiment 2b
Average travel time	X	X	X
Travel costs	X	X	X
Reliability variations around the average travel time		X	X
Arrival time		X	

We set up the *stated-preference* experiments in such a way that the respondents assigned no value to reliability in the section pertaining to average travel time, and vice versa. This was also evident in the data. There was no significant difference in the value for average travel time in the three experiments. This means that on the value side, no double counting occurred. The values for travel time and reliability can be added in the CBA. For application in a CBA, however, it is necessary that the magnitude of change in travel time and reliability (the 'Q') both be determined separately.In this respect, reliability can be measured as the standard deviation around the average travel time.

Representative for all of the Netherlands

Data collection for passenger travel and transport is conducted in two steps. In the first sample survey, the respondents were recruited from the largest online panel (PanelClix) in the Netherlands, which involves 240,000 participants and processing via an internet survey (number of respondents: 5,760). In the second sample study, the respondents were recruited in the same manner as for the previous research study; namely, at petrol stations along the motorways, parking garages, train stations, tram and bus stops, airports (Schiphol and Eindhoven), and marinas (recreational navigation).

Respondents who agreed to participate received a web link to a questionnaire (number of respondents: 1,430). The two surveys differed in their recruitment methods. The questionnaire used was the same. The data collected via the second survey were used to estimate the new VoTs and VoRs. The total data set based on both surveys was used to determine the relationship between the value for travel time and social-economic factors (such as gender, age or income) and trip characteristics (such as long or short journeys).

For freight transport, only *face-to-face* interviews were used, owing to the greater complexity of the survey questions (number of respondents: 812). Respondents – which were logistics managers – were first approached by telephone. If they agreed to participate, an appointment was made for an interview (number of respondents: 812). This sample survey is sufficiently representative for estimating the new VoTs and VoRs. The respondents were recruited in the same manner for the previous major empirical research study of freight transport (2004).

State-of-the-art

This research study incorporates the latest relevant national and international scientific developments. The scientific quality of our research was continuously verified through close collaboration with national and international experts and scientists. In addition, the CPB was involved in the research.

Over the past decade, important developments have occurred in the data analysis method used for estimating the travel time values of passenger transport. In the previous valuation studies, conducted in 1988 and 1997, the travel time values were estimated based on Multinomial Logit (MNL) utility functions. Literature reviews have revealed that these MNL-models have major disadvantages that can cause a bias in the VoT. Various techniques have been developed to prevent these disadvantages from occurring. One possible solution is the use of Panel Latent Class (LC) models. LC-models assume that there exists varying classes of travelers with their own particular VoT. The model estimates the probability that a respondent belongs to one of these classes. The LC-models are advanced MNL-models and fully accepted in international scientific literature. The new VoTs for passenger transport are based on these LC-models (for all technical details, see Significance et al., 2013).

The use of LC-models means that there has been a change of methodology with regard to the old VoTs, which, based on the 1997 survey, were estimated according to the simple MNL utility functions. In order to compare the old and new VoTs for passenger transport with each other, an additional analysis was conducted in which corrections were made for this change of methodology. This is detailed in Chapter 4.

3
The new values for travel time and travel time reliability

This chapter presents the new social-economic values for changes in average travel times and in the reliability of travel times. These figures are representative for the Netherlands. The travel time value, or VoT, expresses the social benefits derived from decreases in average travel times, or conversely the social-economic costs associated with increases in average travel times. The value of reliability, or VoR, expresses the social benefits derived from reducing the dispersion around the average travel time, or conversely the social costs stemming from an increase in this dispersion. The *Reliability Ratio* (RR) expresses the relation between VoT and VoR. The following applies: RR = VoR / VoT, of VoR = RR X VoT.

The new values are also available on the websites of the KiM Netherlands Institute for Transport Policy Analysis: www.kimnet.nl (see 'Figures for Mobility'), and Rijkswaterstaat's Support Centre for Economic Evaluation (SEE): www.rws.nl/see (see '*Overzicht Effecten Infrastructuur*'). The new values replace the previously prescribed values for travel time and reliability.

All costs and benefits in a SCBA should be valued according to the same unit price (CPB, 2011). The unit price is, in principle, the market price, thus including VAT and other cost price-increasing taxes, such as excise tax. In this publication, all VoTs and VoRs are given in market prices.

The stated values detailed in this chapter pertain to the year 2010. Salaries and prices continue to rise over time; therefore, in future years the expected value of time and reliability will be higher. In order to use travel time values in future years, they must be increased in line with inflation and salary developments, according to the methodology detailed in the supplement to the *Directe Effecten op de Leidraad OEI* (Ministry of Transport, Public Works and Water Management, 2004). The rise in the social-economic values for travel time reliability occurs automatically with the increasing value of travel time. The social-economic values for reliability are coupled with the travel time values, via the above-stated *Reliability Ratio*.

Comparisons with recent international value studies reveal that the new VoTs and VoRs for the Netherlands, as detailed in this study, are well in line with the travel time and reliability values used in comparable countries. This applies to both passenger and freight transport (for full details of this international comparative study, see Significance et. al, 2013). Below, we first discuss the new VoTs and VoRs for passenger travel and transport, before then turning our attention to freight transport.

Passenger travel and transport

The VoTs and VoRs for passenger travel and transport are presented on a per person basis and were categorized according to modality and travel purpose. Refer to Appendix B for VoTs specified according to income categories

As was the case in the previous value study (1997), the travel time value for business-related journeys consists of an employee component and an employer component. The employee component is based on the survey's findings and the value that business travelers assign to travel time. The employer section is based on the productivity gains that can be derived from this. The reliability value for business-related travel is differentiated in the same manner.

The social-economic values for cars (see Table 3.1) apply to the drivers. For passengers in cars the value is set at 80% of that for the car drivers[5]. For the first time, the social-economic values for aviation were determined based on empirical research (see Table 3.4). Moreover, values of time for recreational navigation were also for the first time determined based on empirical research (see Table 3.5).

As in the previous value study, the VoTs and VoRs for passenger travel and transport are also now expressed in market prices, which include VAT and other cost price-increasing taxes, such as excise duty[6].

Table 3.1: Car (in Euro/hour per person, market prices, price level 2010)

Trip Purpose	VoT	VoR	Reliability Ratio
Home-to-work	9.25	3.75	0.4
Business	26.25	30.00	1.1
Other	7.50	4.75	0.6
Average (*)	9.00	5.75	0.6

(*) Note: weighting is based on the division of the trip purposes in minutes traveled, derived from OViN 2010.

Table 3.2: Train (in Euro/hour per person, market prices, price level 2010)

Trip Purpose	VoT	VoR	Reliability Ratio
Home-to-work	11.50	4.75	0.4
Business	19.75	22.75	1.1
Other	7.00	4.50	0.6
Average (*)	9.25	5.50	0.6

(*) Note: weighting is based on the division of the trip purposes in minutes travelled, derived from OViN 2010.

5 See *Leidraad OEI* (2000), Part 2 Capita Selecta, appendix F.
6 The cost of a trip for a traveler includes VAT and other cost price-raising taxes.

Table 3.3: Bus/ Tram/ Metro (in Euro/hour per person, market prices, price level 2010)

Trip Purpose	VoT	VoR	Reliability Ratio
Home-to-work	7.75	3.25	0.4
Business	19.00	21.75	1.1
Other	6.00	3.75	0.6
Average (*)	6.75	3.75	0.6

(*) Note: weighting is based on the division of the trip purposes in minutes travelled, derived from OViN 2010.

Table 3.4: Airplane (in Euro/hour per person, market prices, price level 2010)

Trip Purpose	VoT	VoR	Reliability Ratio
Business	85.75	56.00	0.7
Non-business	47.00	30.75	0.7
Average (*)	51.75	33.75	0.7

(*)Note: weighting is based on the division of the trip purpose in minutes travelled, deriving from the own stated preference survey.

The values for recreational navigation relate to waiting times at locks and bridges, not to travel times. Travel time savings are irrelevant in this context, precisely because for recreational navigation the value is derived from the journey itself. Recreational navigation is an important user group of bridges and locks, and the benefits they derive from shorter waiting times can now be satisfactorily included in the cost-benefit analyses (CBA) conducted for investments in these bridges and locks.

Table 3.5: Recreational navigation (in Euro/hour waiting time per person, market prices, price level 2010)

Trip Purpose	VoT	VoR	Reliability Ratio
Other	8.25	0	0

Freight transport

The VoTs and VoRs for freight transport apply per transport, which is the entire vehicle or vessel, for which an average loading factor is calculated. The social-economic values are categorized per modality. In addition, a distinction is made between freight that was or was not transported in containers. In the data collection, a clear distinction is made between the value for the shipper and the value for the carrier. For the value of travel time and reliability, the shipper particularly focuses on: the goods transported, depreciation, interest costs, impact on stock and shutdown of production. The carrier focuses on the so-called factors costs, which are the costs associated with the vehicle or vessel transport (depreciation, maintenance, insurance, fuel) and personnel. For all the below-stated values (Tables 3.6-3.10) the following applies: the value for the shipper and the carrier are added together and included in the value.

The transport costs for companies exclude VAT – which can be returned at a later date – and include other cost price-increasing taxes. The VoTs and VoRs presented here for freight transport are calculated based on market prices, including weighted average percentages for VAT per modality[7], which are available on Rijkswaterstaat's Support Centre for Economic Evaluation (SEE): www.rws.nl/see.

[7] Applied weighted average VAT surcharges: (*) air 15%; (*) sea 15%; (*) road 10%; (*) inland waterway 11%; (*) rail 18%.

Road freight transport
In the previously conducted major empirical research study (2004), trade-off ratios (TRs) were derived for all modalities of freight transport. These trade-off ratios reveal how travel time and factor costs for freight transport can be exchanged between each other. The TR is the multiplier for calculating factor costs into travel time values. The following applies: VoT = TR X factor costs. The factor costs for all modalities are known, as based on factor cost research studies, the latest of which was conducted in 2011 (NEA, 2011).

In this research study it proved possible to estimate utility functions for road transport from which VoTs could be derived directly. This provides more accurate results than VoTs derived via indirect TRs and factor costs (see Table 3.6).

Table 3.6: Road (in Euro/hour per truck, market prices, price level 2010)

Containers	VoT	VoR	Reliability Ratio
Yes	64.40	4.10	0.06
No	40.50	16.7	0.41
Average (*)	42.20	15.80	0.38

(*) Note: the weighting factors used are 0.07 (containers) and 0.93 (non-containers).

Non-road freight transport
Research has shown that it is not feasible to directly derive the VoTs for the modalities railway, inland waterway, sea and air; consequently, one must refer back to the method used in the previous study, namely: first derive the TR-ratios, and then, via the factor costs, determine the VoTs; see Tables 3.7-3.10. The TR-ratios are given in brackets. If, in specific studies, a further distinction is needed between, for example, types of inland waterway vessels, this can be determined by multiplying the TR-ratio with the factor costs for that particular vessel type. The factor costs for the various modalities and types are available in the NEA (2011).

To date, TR=1[8] is always incorporated in the CBA. Based on the recommendation stemming from the research study (Significance et. al, 2013), KiM has decided to abandon this approach. For the new VoTs, the TRs are deemed to grow linearly from the completion of an infrastructure project to TR=1 over a 10-year period. The TRs to which this applies are detailed in Tables 3.7-3.10. The growth to 1 over a 10-year period is indicated in the tables with 'TR= TR at completion of project → 1 '.

Explanation
A new road, railway line, harbor quay, lock or runway is constructed over the long term. An hour of travel time savings in the first few years will not always be fully utilized by the shipper or carrier, as their business processes are not yet fully adapted to the new situation; consequently, for example, the personnel required for a new assignment can be engaged but not yet the means of transport. The VoT therefore can be lower than the factor costs. Over time the shipper or carrier will be in a better position to efficiently utilize the transport hours gained. Furthermore, when the benefits of a project continue to diminish in future, the TR ratio will increase to 1. After ten years or more, the calculation is performed using TR=1.

[8] This means VoT= factor costs.

Table 3.7: Rail (in Euro/hour per train, market prices, price level 2010)

Containers	VoT	VoR
Yes	1,040 (TR= 0.52→ 1)	120 (RR=0.12)
No	1,390 (TR= 0.42→ 1)	299 (RR=0.21)
Average (*)	1,270 (TR=0.46→ 1)	236 (RR=0.19)

Note: When an infrastructure project is completed, TR grows linearly to 1 over a 10-year period;
(*) the weighting factors used are 0.35 (containers) and 0.65 (non-containers).

Table 3.8: Air (in Euro/hour per airplane, market prices, price level 2010)

Containers	VoT	VoR
Yes	n/a	n/a
No	14,900 (TR=0.72→ 1)	1,860 (RR=0.13)
Average	14,900 (TR=0.72→ 1)	1,860 (RR=0.13)

Note: When an infrastructure project is completed, TR grows linearly to 1 over a 10-year period.

Unlike in the previous empirical research studies, the values for inland waterway and sea shipping apply to waiting times at locks, for bridges and for unloading and loading at harbor quays (Tables 3.9 and 3.10), but they have no relation to travel time. Following discussions with inland waterway and sea shipping sector organizations about the *pilot* study, it emerged that questions about total travel times were unrealistic in practice and not well understood within the sector, while, conversely, questions about waiting times at locks, for bridges or on the quay were well understood. Benefits that inland waterway and sea transport derive from shorter waiting times resulting from investments in locks, bridges or quays can be included in cost-benefit analyses via these values.

Table 3.9: Inland waterways (in Euro/hour waiting time per ship, market prices, price level 2010)

Containers	VoT	VoR
Yes	Quay: 108.70 (TR=0.33→ 1) Lock: 382 (TR= 1.16) Bridge: 382 (TR= 1.16)	Quay: 19.80 (RR=0.18) Lock: 29.70 (RR=0.08) Bridge: 29.70 (RR=0.08)
No	Quay: 71.90 (TR=0.23→ 1) Lock: 331 (TR=1.06) Bridge: 331 (TR=1.06)	Quay: 28.10 (RR=0.39) Lock: 28.10 (RR=0.08) Bridge: 28.10 (RR=0.08)
Average (*)	Quay: 76.70 (TR=0.24 → 1) Lock: 338 (TR=1.07) Bridge: 338 (TR=1.07)	Quay: 27 (RR=0.35) Lock: 28.30(RR=0.08) Bridge: 28.30 (RR=0.08)

Note: When an infrastructure project is completed, TR grows linearly to 1 over a 10-year period;
(*) the weighting factors used are 0.13 (containers) and 0.87 (non-containers).

Table 3.10: Sea transport (in Euro/hour waiting time per ship, market prices, price level 2010)

Containers	VoT	VoR
Yes	Quay: 871 (TR=0.76→ 1)	Quay: 51 (RR=0.06)
No	Quay: 957 (TR=0.66→ 1)	Quay: 131 (RR=0.14)
Average (*)	Quay 941 (TR=0.68→ 1)	Quay: 115 (RR=0.12)

Note: When an infrastructure project is completed, TR grows linearly to 1 over a 10-year period;
(*) the weighting factors used are 0.19 (containers) and 0.81 (non-containers).

4

Differences between old and new travel time values

4.1 Introduction

Travel behaviour changes over time. Consequently, differences between old and new values of travel time may arise, owing to, for example, an improved utilization of travel time by means of ICT (mobile phones, laptops or tablets). In addition, differences arise as a result of new scientific insights and developments that render changes in methodology necessary.

This research incorporates the latest relevant national and international scientific developments. Important developments have occurred in the data analysis method for estimating travel time values of passenger transport. This means a change of methodology with regard to the old VoTs, which were estimated based on the previous survey (1997). In order to clearly compare the old and new VoTs for passenger transport, an extra analysis was performed in which corrections were made for the change of methodology. From this we can see how VoT increased over time and if this corresponds to our theoretical assumptions about the matter, such as is detailed in the supplement to the *Leidraad OEI* for direct effects (Ministry of Transport, Public Works and Water Management, 2004, p.25).

There is also a change of methodology for freight transport. In the previous major research study (2004), the VoTs for all modalities were determined based on *trade-off* ratios (TRs) and factor costs. In this research study, the VoTs for road transport are derived directly from the utility functions. This is unfeasible for other modalities and is calculated according to the previous study's methodology.

For future investment decisions based on social cost-benefit analyses, it is interesting to know if and how the old and new travel time values differ from one another – not only per modality but also for the modalities with respect to each other. By old travel time values, what we mean are the travel time values that until now have been applied in the CBA.

In this chapter we first examine the differences between the old and new travel time values for both passenger and freight transport (section 4.2). We then make clear comparison between the old and new VoTs for passenger travel by correcting for the change of methodology (section 4.3). From this we can draw conclusions about the growth of travel time value over time.

4.2 Comparing the old and new travel time values

Below we compare the old and new travel time values for both passenger and freight transport with each other. By old travel time values, we mean the travel time values that until now have been applied in the CBA (annually increased in line with inflation and wage developments) and are published on Rijkswaterstaat's Support Centre for Economic Evaluation (SEE) website: www.rws.nl/see.

The old travel time values for passenger transport are based on the *stated-preference* research conducted in 1997. In order to express this in today's value, the values were continuously increased over time in line with inflation and wage developments, according to the methodology described in the supplement to the *Leidraad OEI* for direct effects (Ministry of Transport, Public Works and Water Management, 2004, p.25). The old travel time values for freight transport are based on *stated-preference* research conducted in 2004 and were continuously increased over time in line with inflation and wage developments. By new travel time values, we mean the travel time values based on this study.

We first look at the differences for passenger travel and transport, and then focus our attention on freight transport.

Passenger travel and transport

The new VoT for car travel is on average some 16 percent lower than the current value (Table 4.1). Travelers with other/recreational purposes for their trip value an hour of travel time higher than do business-related travelers. One plausible explanation for car travel's lower valuation is the increasing use of mobile telephones during journeys, since part of the travel time can therefore be spent usefully. The disutility aspect of a journey decreases and one hour of travel time savings is valued less. This is called 'journey time enrichment'. In the following section we focus on the possible effect journey time enrichment will have on the future growth of VoT

Table 4.1: Car (VoTs in Euro/hour per person, market prices, price level 2010)

Trip Purpose	Old	New	Difference (in %)
Home-to-work	9.55	9.25	-3%
Business	33.07	26.25	-21%
Other	6.59	7.50	+14%
Average (*)	10.67	9.00	-16%

(*) Notes: weighting is based on the division of the trip purposes in minutes travelled , derived from OVG 1995 (old VoTs) and OViN 2010 (new VoTs).

For trains, we see an increase in the value of travel time, except for the business traveler segment (Table 4.2). A key question is why journey time enrichment for trains has not been as prominent as with cars, given that trains potentially offer equally good opportunities to work during journeys. Perhaps overcrowded trains – in which it is difficult to find a seat – play a role in this. Moreover, perhaps this is also because the concept of journey time enrichment has existed for much longer with trains; for example, take the fact that it has always been possible to read work reports in the train, whereas the added value from ICT developments here remains limited when compared with cars. Perhaps some degree of progress can be expected as Wi-Fi is introduced in all trains.

For trains in particular the ability to clearly distinguish between long and short journey distances has had an upwards effect on the VoT of trains. In the previous value study (1997), it was not yet possible to distinguish between longer and shorter journeys in the models that estimated travel time value. Now however this is possible. Longer journey distances have on average higher VoTs than shorter distances. This is partly due to the associated fatigue levels and lack of comfort, which are more prevalent the longer journeys last, and partly due to the fact that converting one hour of travel time into leisure time has more value if people are left with less leisure time (owing to a longer journey time). Train passengers on average travel longer distances than people who travel by car, bus, tram or metro (B/T/M).

Table 4.2: Train (VoTs in Euro/hour per person, market prices, price level 2010)

Trip Purpose	Old	New	Difference (in %)
Home-to-work	9.62	11.50	+20%
Business	20.36	19.75	-3%
Other	5.93	7.00	+18%
Average (*)	7.58	9.25	+22%

(*) Note: weighting is based on the division of the trip purposes in minutes travelled , derived from OVG 1995 (old VoTs) and OViN 2010 (new VoTs).

Table 4.3: Bus/ Tram/ Metro (VoTs in Euro/hour per person, market prices, price level 2010)

Trip Purpose	Old	New	Difference (in %)
Home-to-work	8.93	7.75	-13%
Business	15.56	19.00	+22%
Other	5.65	6.00	+6%
Average (*)	6.63	6.75	+2%

(*) Note: weighting is based on the division of the trip purposes in minutes travelled , derived from OVG 1995 (old VoTs) and OViN 2010 (new VoTs).

This is the first time that empirical social-economic values of time for air travel have been established using a *stated preference* survey (the new VoTs in Table 4.4). The old VoTs for air travel were calibrated with SEO's NetScan-model (2011) and therefore are unsuitable for making comparisons with the VoTs derived from this empirical study. In addition, the VoTs, as based on the NetScan-model, provide the travel time value for international air passengers in general. The VoTs in this study provide the travel time value for Dutch air passengers.

Table 4.4: Airplane (VoTs in Euro/hour per person, market prices, price level 2010)

Trip Purpose	Old	New	Difference (in %)
Business	52.00	85.75	+65%
Non-business	24.00	47.00	+96%
Average	33.24 (*)	51.75 (**)	+86%

(*) Note: weighting is based on the division of the trip purposes as expressed in the number of air passengers at Schiphol, according to the Schiphol survey conducted in 2010[9].
(**) Note: weighting is based on the division of the trip purpose in minutes travelled , deriving from the own stated preference survey[10].

[9] Business 33%; non-business: 67%.
[10] Business 12.3%; non-business 87.7%.

Reliability gains from road projects
Because there is a lack of sufficient information about the actual effects that policy measures have had on travel time reliability, to date a mark-up in travel time savings is used when calculating the reliability gains. This is as follows: reliability benefits = travel time benefits X 0.25. This mark-up percentage of 25% is derived from the CPB (2004). The mark-up may only be applied to road projects. Moreover, the mark-up may only be applied if congestion is an issue in the baseline situation.

Because the applied mark-up of 25% is a rough average, the reliability benefits for specific reliability projects can be over- or underestimated. In addition, the mark-up method only reveals the reliability benefits if there are also travel time savings. A specific example is as follows:

KiM has conducted research into the effects on the average travel time and the variation around that average resulting from the addition of 78 extra lanes on the main road network during the period 2000-2011 (Van der Loop et al., 2012). For this the effects of these measures on the travel time and the variation around the travel time were effectively measured. Moreover a distinction was made between high and low levels of congestion. To determine the reliability benefits, a *reliability ratio* of 0.6 for passenger car transport and 0.37 for freight transport was used (see Chapter 3). We can express the reliability benefits revealed from this in a mark-up of the travel time benefits. For a high level of congestion, the reliability benefits for passenger transport are 36% of the travel time benefits, and 22% for freight transport. For a low level of congestion, those figures are 24 and 15 percent, respectively. These percentages are above and below the average standard mark-up of 25%, which has been used to date.

It is important to avoid the mark-up approach as much as possible for those projects in which the specific objective is to increase the reliability of travel time. Precisely for these types of projects, the project effects on travel time reliability must be mapped accurately and valued with the VoR.

From the start the CPB meant for this mark-up approach to be temporary and replaced when information about the effects certain measures had on increases in travel time reliability became available, in conjunction with values for the social-economic value of these effects.

For the first time the values in this study were determined based on empirical research. In order to map the effects policy measures have on reliability, the reliability must be included in traffic and transport models (such as the LMS and NRM). Subsequently, the reliability benefits for specific reliability projects can be better included in a CBA. This also applies to projects in which reliability benefits emerge due to a lower than average speed limit, examples of which are found in environmental and safety investments. Thus, incident management and measures aimed at preventing accidents often also provide reliability benefits.

Reliability gains from non-road projects
There is also a lack of satisfactory information about the effects policy measures have on the reliability of travel times for other modalities (train, bus/tram/metro and airplane). In addition, there is no temporary calculation rule available, such as the 25% mark-up used for road traffic. Consequently, the reliability savings that derive from investments in this infrastructure cannot be included in the cost-benefit analyses.

Freight transport
This research study has shown that it is in fact possible to derive the VoTs for road transport directly from the utility functions (Table 4.5). This provides more accurate results than does deriving the VoT via indirect TRs and factor costs, as was done in the previous major research study (2004). This change of methodology is the reason for the differences between the old and new VoTs in truck freight transport.

As in the previous research study, the VoTs for other modalities (rail, inland waterway, sea and air) were derived from the TRs and factor costs. Here, another change of methodology is the reason for differences between the old and new VoTs. To date, TR=1 has always been incorporated in CBAs. Based on recommendations stemming from the research (Significance et. al, 2013), KiM decided to abandon this approach, as explained in Chapter 3. For the new VoTs, the TRs are deemed to grow linearly from the completion of an infrastructure project to TR=1 over a 10-year period (this is presented in Table 4.6 as 'TR at completion of project→ 1').

Table 4.5: Road (VoTs in Euro/hour per truck, market prices, price level 2010)

	Old	New	Difference (in %)
Average transport	50.36	42.20	-16%

Table 4.6: Non-road modalities (trade-off ratios average transport)

Modality	Old	New (*)	Difference (in %)
Rail	1	0.46 → 1	-13%
Inland waterway, lock	1	1.07	+7%
Sea, quay	1	0.68→ 1	-8%
Air	1	0.72→ 1	-7%

Note: (*) When an infrastructure project is completed, TR grows linearly to 1 over a 10-year period. The column 'difference' is calculated based on this growth, a net present value calculation over 100 years, and a discount rate of 5.5%.

When stating the differences between the old and new VoTs, it is important to remember that – unlike in the previous research study – the values for inland waterway and sea transport are not related to travel time, but rather to the waiting times at locks, for bridges or loading and unloading at harbor quays (see Chapter 3).

Reliability gains

Because there is a lack of satisfactory information about the actual effects policy measures have had on travel time reliability, to date a mark-up of 25% for truck freight transport is used when calculating the reliability gains, which applies to road transport (see previous explanation of this issue) [11].

Rijkswaterstaat Water, Traffic, and Environment (WVL) developed a mark-up rule that is based on empirical research and can be used to determine the reliability benefits of waterway projects for the inland waterways, namely: reliability benefits = benefits from savings on waiting times at bridges and locks X 0.15. As is the case for mark-up rule used for road transport, this mark-up is also meant to be temporary and replaced when information about the effects of policy measures on travel time reliability becomes available.

There is also a lack of satisfactory information about the effects of policy measures on the reliability of travel times for other modalities (rail, sea and air), and moreover no temporary calculation rule available. Reliability gains that can be achieved for these modalities therefore cannot be included in cost-benefit analyses.

[11] That is: reliability benefits = travel time benefits X 0.25. This mark-up percentage of 25% is taken from the CPB (2004). The mark-up may only be applied to road projects. Moreover, the mark-up may only be applied if congestion is an issue in the initial situation.

4.3 Travel time enrichment in passenger travel and transport

Over the past 10 years important developments have occurred in the data-analysis method used for estimating travel times for passenger travel and transport. This study incorporates the latest insights. In order to be able to clearly compare the old and new VoTs with each other, corrections were made for this change of methodology by also analyzing the 1997 survey data with the method used in 2010. In order to correct for inflation, the VoTs from 1997 are expressed in the euro values of 2010. Comparing the corrected VoTs for 1997 (corrected for inflation and the change of methodology) with the VoTs from 2010 provides the actual VoT growth levels for the period 1997-2010 (see Table 4.7).

Table 4.7: Actual growth in travel time for passenger travel and transport from 1997 to 2010

	Car	Train	Bus/ Tram/ Metro
Home-to work	-19%	+17%	-23%
Business	-19%	+28%	+66%
Other	+39%	+27%	+20%

Note: This table shows the comparison between the corrected VoTs from 1997 and the VoTs from 2010. The 1997 VoTs were corrected for inflation and the methodological time series break.

We can expect that over time the actual travel time value will increase as real incomes increase. In order to use the travel time value for future years, they must also be increased in line with wage developments, according to the methodology detailed in the supplement to the *Directe Effecten op de Leidraad OEI* (Ministry of Transport, Public Works and Water Management, 2004, p. 25). For this an income elasticity of 0.5 is applied. According to this calculation method, we can therefore expect a growth of approximately +15% in all cells in Table 4.7. Reality reveals something different, however. Based on these outcomes, the calculation method with which we increase VoTs for future years in line with wage developments should be reviewed.

Journey time enrichment could be one possible explanation for a growth level below +15%. Owing to the ICT developments and the use of ICT during journeys, the disutility aspect of a journey could decrease, whereby an hour of travel time savings will be valued lower. The journey time enrichment phenomenon was first described by Hugh Gunn (2001). He concluded that, despite the sharp rise in income levels, the real value for changes in travel time in the Netherlands during the period 1988-97 remained relatively constant. In Table 4.7 we see that this trend for car use has become more pronounced and that the actual growth of VoT during the post-1997 years was in fact negative. In other words, shorter travel times resulting from infrastructure investments will be valued lower in future, while comfort benefits (ease and convenience) through investments in the means of transport itself become increasingly more important. Potentially, we expect this trend to also occur for trains. Research studies focused on the value of convenience factors, comfort, and how such factors can be quantitatively included in CBAs are, however, still in their infancy.

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APPENDIX A: Abbreviations

B/T/M	Bus/ Tram/ Metro
CBA	Cost-Benefit Analysis
CPB	Netherlands Bureau for Economic Policy Analysis (Centraal Planbureau)
CBRB	Centraal Bureau voor de Rijn- en Binnenvaart
DGB	Directorate-General Reliabilty (*Directoraat-generaal Bereikbaarheid*)
EVO	Ondernemersorganisatie voor logistiek en transport
ICT	Information ann Communication Technology
IenM	Ministry of Infrastructure and the Environment
ITF	International Transport Forum
KiM	Netherlands Institute for Transport Policy Analysis
LC	Latent Class
LMS	National Model System Traffic and Transport (*Landelijk Model Systeem Verkeer en Vervoer*)
MIRT	Multi-Year Programme for Infrastructure, Spatial Planning & Transport (Meerjarenprogramma Infrastructuur, Ruimte en Transport,)
MNL	Multinomial Logit
NRM	New Regional Model
OECD	Organization for Economic Co-operation and Development
OEI	Overview Effects Infrastructure (*Overzicht Effecten Infrastructuur*)
OV	Public Transport (*Openbaar Vervoer*)
OVG	Travel Behaviour Research (*Onderzoek Verplaatsingsgedrag*)
OViN	Travel in the Netherlands Research (*Onderzoek Verplaatsingen in Nederland*)
RR	Reliability Ratio
SCBA	Social Cost-Benefit Analysis
SEE	Support Centre for Economic Evaluation (*Steunpunt Economische Evaluatie*)
TLN	Transport en Logistiek Nederland
TR	Trade-off ratio
TU	Technical University
VAT	Value Added Tax
VenW	Ministry of Transport, Public Works and Water Management
VoR	Value of Reliability
VoT	Value of Time
WVL	Rijkswaterstaat Water, Traffic and Environment (Water, Verkeer en Leefomgeving)

APPENDIX B: VoTs per income category

As was also the case in the previous study of travel time values (1997), the VoTs for passenger travel and transport are categorized per income class.

Table B1: VoTs in Euro/hour per person, market prices, price level 2010

Net income per household per month in euros	Car	Train	B/T/M (*)	Airplane	Recreational navigation
< 1,875	8.75	9.50	6.00	29.25	8.25
1,875- 3,125	9.50	11.00	6.50	36.50	8.25
3,125- 4,325	8.25	13.80	7.00	36.50	8.25
> 4,325	10.50	14.25	11.75	47.75	8.25

(*) Note: B/T/M= Bus/ Tram/ Metro

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KiM Netherlands Institute for Transport Policy Analysis
Postbox 20901
2500 EX Den Haag
The Netherlands

Telephone: +31 (0)70 456 1965
Fax: +31 (0)70 456 7576

Website: www.kimnet.nl
E-mail: info@kimnet.nl

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