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NEW SP-VALUES OF TIME AND RELIABILITY FOR FREIGHT TRANSPORT IN THE NETHERLANDS

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Abstract
This paper discusses the methods used in a study on the values of time and reliability in freight transport in the Netherlands. SP surveys were carried out among more than 800 shippers and carriers. A novel feature is that both for the value of time and reliability two additive components are distinguished: a transport cost and a cargo component. Specific instructions were given to make sure that the carriers provide the former and shippers that contract out the latter component. The resulting values that will be used in CBA in The Netherlands are presented and compared against the international literature.

Highlights

- Two components in the VOT and VOR are distinguished: the transport cost and the cargo component. Specific instructions are given to shippers that contract out and carriers in the SP so that their values of time and reliability will be the cargo and the transport cost component respectively and become additive.
- Presentation of reliability in the form of five equi-probable transport and arrival times.
- Estimation of a VOR in using the standard deviation of transport time in the utility function, which has been uncommon in freight transport, but can relatively easily be included in forecasting models.
- New SP context for sea and inland waterway transport.
- The data set used possibly is the largest SP survey carried out in freight transport (in terms of number of interviews).
- Presentation of new values for The Netherlands (which other countries can use for comparison, benchmarking or even value transfer) and comparison with the existing literature.

Keywords: value of time, value of reliability, value of variability, freight transport, stated preference.

1. INTRODUCTION

1.1 Background and objectives

Values of Time (VOTs) and Values of Reliability (VORs) are crucial for converting the impacts of transport projects into monetary units. This enables policy makers to include the savings in time and reliability in the Cost-Benefit Analysis (CBA) of these projects. In the Netherlands, the current freight VOTs are based on Stated Preference (SP) research carried out in 2003/2004 (RAND Europe et al., 2004). The current VORs were derived from the same survey, but for this many additional assumptions[2] had to be made (de Jong et al., 2009).

Including benefits from reduction in travel time variability in CBA is important, since otherwise the benefits from transport investment and possibly also environmental and safety investments may be underestimated. For example, new or wider roads can reduce travel times and travel time variability, the reduction of the maximum speed limit may lead to a lower average speed and hence costs related to travel time losses, but this may be compensated by benefits due to higher reliability of travel times. Also, investments in incident management may lead to additional benefits due to improved travel time reliability.

This study is one of the first large scale stated preference studies in freight transport that not only seeks to identify VOTs but also VORs, for inclusion in an official (government-adopted) project appraisal framework.

Overviews of the methods used and results obtained in value of time research in freight transport around the world can be found in Zamparini and Reggiani (2007), de Jong (2008) and Feo-Valero et al. (2011). The international literature on the value of reliability in freight transport is much more limited. An overview (in German) is provided in Significance et al. (2012a).The key result from this review is that most empirical outcomes for the value of reliability in freight transport relate to the fraction of transports that arrives too late (sometimes with a minimum lateness threshold). Models using a dispersion measure such as the standard deviation of transport time are scarce (recent evidence for this measure will be discussed in section 5), and even more so are models that use explicit terms for the degree of earliness and lateness from the Vickrey-Small scheduling model (Vickrey, 1969; Small, 1982). These are the two definitions of unreliability of transport time that are used most in the passenger transport literature (see for instance Carrion and Levinson, 2012).

[2] Important assumptions are that travel time and arrival time follow the same distribution and that there is a certain mix between reducing buffer time and lateness.

In earlier projects (RAND Europe, 2004; Hamer et al., 2005; HEATCO, 2006), the choice was made to measure the variability of transport time in the Netherlands by the standard deviation of the travel time distribution. The main reason behind this choice was the assessment that including travel time variability in transport forecasting models would be quite difficult, and that using the standard deviation would be the easiest option. Any formulation that would go beyond the standard deviation of transport time (or its variance) would be asking too much from the current (and near-future) national and regional transport models that are used in CBA in The Netherlands. As such, this study is one of the first to provide a value of reliability in freight transport in the form of the standard deviation of transport time (we know two other studies that have provided such a measure, see section 5).

This paper describes the work carried out in a project for the Dutch Ministry of Infrastructure and the Environment to obtain up-to-date, evidence-based monetary values of time (VOTs) and values of reliability (VORs) in freight transport (more detail can be found in the project's final report: Significance et al., 2012b). The VOTs will replace the existing values; the VORs will be the first of their kind for the Netherlands. This project also dealt with passenger transport, but this is treated in a separate paper (Kouwenhoven et al., 2013).

1.2 Headlines of the methodology

The data collection for freight transport was carried out in 2010. Shippers and carriers were interviewed using computerised stated preference face-to-face interviews, resulting in a, for freight transport, relatively large data base of more than 800 interviews. Specific target numbers of interviews were set for transport mode used (road, rail, air, inland waterways and sea transport), for containerised or not containerised shipment and for shipper versus carrier. This data set is possibly the largest SP survey ever collected in freight transport, in terms of the number of interviews carried out (slightly larger than the Norwegian freight SP survey reported in Halse et al., 2010, with more carriers and fewer shippers).

Shippers that contract their transport out were asked to select a "typical transport (using a prescribed mode) that is regularly carried out for your firm by a carrier (this shipment is representative for your firm in terms of packaging, distance, destination, etc." Carriers (and shippers with own transport) were asked to select a "typical transport (using a prescribed mode) that is regularly carried out by your firm (this is a shipment that is representative for your firm in terms of packaging, distance, destination, etc.)" We found that for most carriers this typical transport was equivalent to a loading unit such as a container or truckload, whereas for shippers the typical transports were mostly shipments in the sense of an amount of goods that leave a sending firm (e.g. manufacturer) for a receiver at the same time.

The main innovation in freight SP survey methods that was introduced in this study was the specific instructions concerning those considerations related to the cargo and those related to the transport services for shippers and carriers. In considering the trade-offs, carriers were asked to reflect on those aspects that are related to the provision of transport services such as transport staff and vehicles. Shippers that contract transport out were asked to consider the aspects related to the goods themselves (e.g. capital costs on inventory in transit). Finally, shippers with own account transport were requested to include all these elements in their trade-offs. The result of this is that we obtain a transport cost component for the VOT and VOR from the carriers and a cargo component from the own account shippers, which can be added to get the overall VOT and VOR.

For reliability, a non-graphical presentation by means of a series of five equi-probable transport times (and corresponding arrival times) for each alternative was used in the SP experiments. This study is one of the first to use this format in freight transport (a similar but not identical format was used in Halse et al., 2010; see section 2).

For inland waterways and maritime transports we developed new SP experiments focusing on waiting time at a lock, bridge or terminal quay (but without presenting arrival times). As far as we are aware, SP experiments in these contexts have not been done before. Nevertheless these are precisely the contexts of most (publicly financed) transport investment projects in inland waterway and sea transport (new or renewed locks and bridges, port capacity extensions) that are proposed in practice.

The interview data were used for the estimation of absolute and relative multinomial logit models on the SP data, with and without interaction variables and with and without variables to test elements of prospect theory (such as different values for gains versus losses). We were not able to obtain stable estimates from mixed logit (random coefficients) or latent class models, due to the still insufficient number of observations, given the degree of heterogeneity. We accounted for repeated measurements among the same individuals by means of the Jackknife method (Cirillo et al., 2000).

The parameters needed for obtaining the VOR for cost-benefit analysis were estimated, using both the mean-standard deviation and the scheduling approach. For the recommended values for CBA, the mean-standard deviation approach was used. The VOR thus derived implicitly includes the costs of travel time variability due to scheduling costs.

Since the interviewees were asked to consider a typical transport (shipment), the VOTs that we obtained were initially per shipment. However, we converted this into values per vehicle/vessel, which is the most appropriate unit for use in CBA.

The paper presents the design of the SP survey (section 2) and statistics for the sample obtained (section 3). The estimation results are discussed in section 4 and outcomes derived from these models referring to the values of time and reliability are given in section 5. These values are also compared to those from previous surveys in The Netherlands and the international literature. Finally, in section 6, conclusions are drawn.

2. THE SP SURVEYS

2.1 A priori expectations for the VOT of shippers and carriers

Table 1 summarises the assumptions (a priori hypotheses) we make on the extent to which particular actors take into account different components of the freight value of time – and are asked to do so, when responding to our stated choice questions.

Table 1: Hypotheses on the aspects that freight respondents include in their VOT

	VOT related to cargo	VOT related to vehicles and staff
Carrier	Not included	Included
Own account shippers	Included	Included
Shipper that contracts out	Included	Not included

Carriers are in the best position to give the VOT 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. Results in the Netherlands and other countries so far indicate that the VOT that is related to the transport services is indeed more or less equal to the vehicle and labour cost per hour (the ‘factor cost’), at least for road transport (see de Jong, 2008).

Shippers that contract out are most interested in the VOT 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 (usually only important for high-value goods), the potential 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 VOR.

Shippers with own account transport can naturally give information on both the VOT that is related to the costs of providing transport services and the VOT that is related to the goods themselves.

If both VOT components are properly distinguished, the carrier VOT and shipper (contract out) VOT can be added to obtain the overall VOT, as is sought in this study. Previous studies have not tried to disentangle these two VOT components, but in the current study we will obtain estimates for both components separately.

Of course there may be exceptions to the general pattern identified in Table 1, but in the freight questionnaires we 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). We did this by giving very explicit instructions and explanations to get clearly defined component values from each type of agent. In other words:

1. We 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.
2. We explained to carriers (and logistics service providers) that a shorter transport time might be used for other transports: the staff and vehicles/vessels can be released for other productive activities. An improvement in reliability means that the carrier can be more certain about such re-planning/re-scheduling. We also explained that they do not have to take into account what would happen to the goods if they were late (deterioration, disruption of production process, running out of stock, etc.).
3. We explained to shippers that contract out that they only have 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. Whether these things would occur and how important they are was left to the respondent (i.e., the shipper).
4. We explained to shippers with own account transport that they have to take both these effects (=cargo and vehicle) into account.

2.2 Set-up of the questionnaire (for all shippers and for carriers in road, rail and air transport)

The questionnaire consisted of the following parts:

1. Questions regarding the firm (e.g. sector, number of employees, modes used).
2. Selection of a typical transport and questions on the attributes of this transport, such as transport time and costs. These values are used as base levels for the attribute levels presented in the SP experiments (the

unreliability levels presented in the SP are aligned with the observed transport time, but are not based on an individually observed degree of unreliability).

3. Questions on the availability of other modes for this transport and what the attribute levels would be for that mode. For the carriers this referred to a different route rather than a mode.
4. SP experiment 1 (six choices between two alternatives both referring to the same mode, each described by two attributes: transport time and transport cost).
5. Introduction to the variability of transport times
6. SP experiment 2a (six within-mode choices between two alternatives, each described by four attributes: transport time, transport cost, transport time reliability and arrival time).
7. SP experiment 2b (seven within-mode choices similar to experiment 2a but without the variation in the usual arrival time. One of the choice pairs in experiment 2b had a dominant alternative).
8. Questions in which the shippers or carriers were asked to evaluate the choices they made in the experiments.

The statistical design is the same for all respondents. Experiment 1 uses a Bradley design (Bradley and Daly, 1992) with two attributes, both with five levels, and experiment 2a an orthogonal factorial design with four attributes, each with five attribute levels. Experiment 2b uses an extended Bradley design with three attributes, each with five levels. The transport time levels offered in the experiments consist of the observed time as well as absolute changes in transport time (e.g. from one minute to twelve hours in road transport) pivoted around the observed time. For transport cost we offer the observed cost level and percentage changes varying between -15% to +25% around the observed level (for a detailed description of the attribute values presented in the SP experiments, see Annex 2). Only the variation in levels is dependent on the type of transport. Many respondents cannot be expected to understand standard deviations, so reliability was presented as a series of five equi-probable transport times, described only verbally, not graphically (see Tseng et al. (2009) for a justification of this approach based on pilot testing for the current project). This presentation format worked very well in in-depth pilot exercises. It is also the same format that was used for the new passenger transport study, where reliability ratios[3] between 0.4 and 1.1 were obtained for surface transport (see Significance et al., 2012b). The only other application in freight transport for this presentation format is Halse et al. (2010), but unlike this Norwegian study, we also present the departure time and five possible

[3] The reliability ratio (RR) measures the importance of reliability (measured as the standard deviation of transport time) relative to transport time.

arrival times (corresponding with the five possible transport times), which makes it possible to test scheduling models on the same SP experiments.

Carriers in road, rail and air transport and all shippers took part in all three experiments (1, 2a and 2b). Carriers using sea and inland waterways only participated in experiment 1 and 2b which were different in nature (see Section 2.3).

Experiment 1 can only give a VOT. Experiment 2a and 2b can give both a VOT and a VOR, and can also be used to distinguish between model specifications with and without explicit scheduling terms.

Figure 1 contains a screenshot of the original interview in Dutch, showing a choice situation in experiment 2a. 'Vertrektijd' is departure time. Then, we explain that the respondent has an equal change on any of five transport times with corresponding arrival times ('Aankomsttijd'). The bottom two attributes are usual transport time and transport cost.

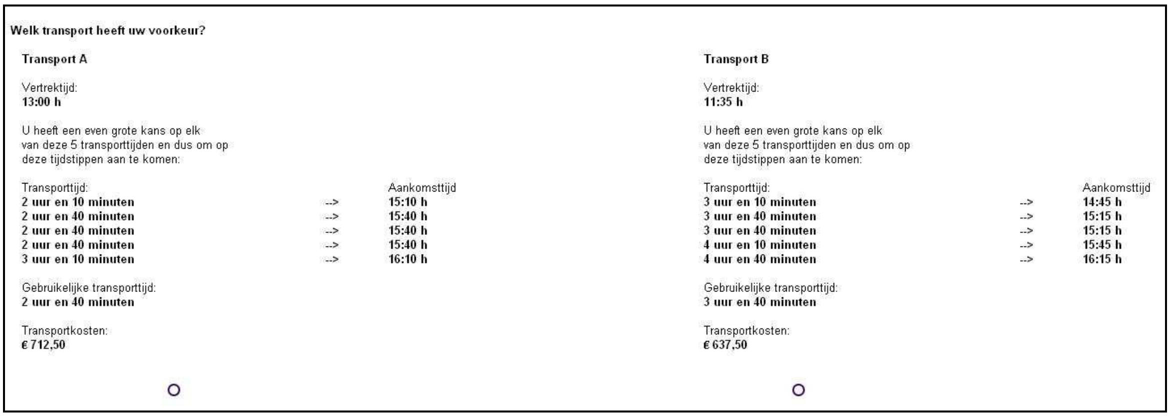

Figure 1: Screenshot of SP question of experiment 2a for shippers and carriers (excluding carriers using sea and inland waterways)

2.3 SP experiments for carriers using sea and inland waterways transport

For transporters in sea and inland waterways transport, discussions with professionals from the sector led us to choose a different setting. The main uncertainty in transport times for these modes does not occur on a river/canal or sea link, but at locks, bridges and ports. CBAs for these modes usually relate to the introduction or replacement of locks and bridges and the extension of port capacity. Therefore we used an new setting for the SP experiments, where a ship is waiting for a lock, bridge or to be loaded/unloaded at a quay in the port. An example of an SP choice situation is presented in Figure 2. The attributes here are five equi-probable waiting times, average waiting time (in this example waiting for a lock) and total transport cost.

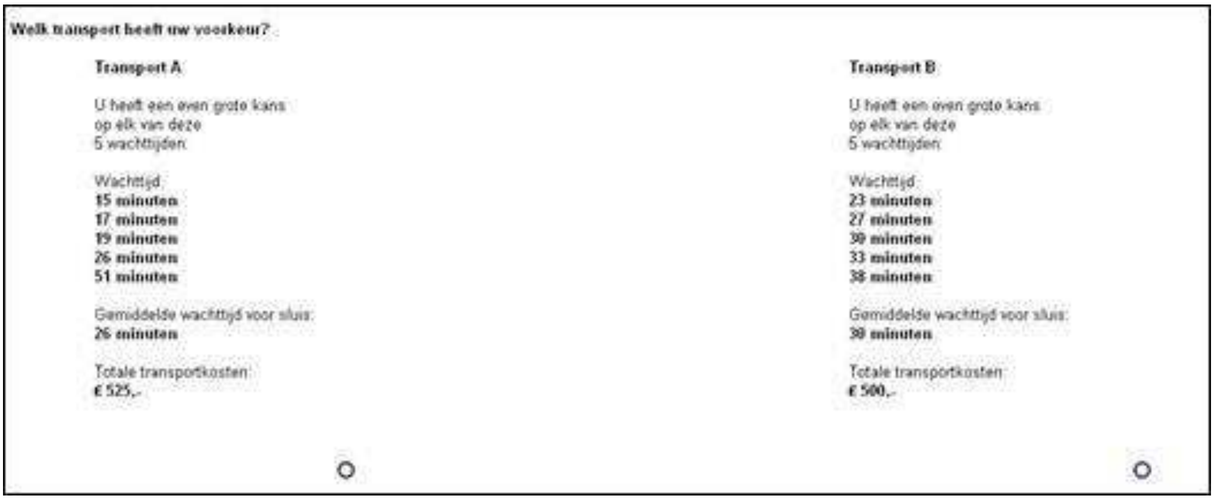

Figure 2: Screenshot of SP question of experiment 2b for carriers using sea and inland waterways

For this experiment no departure and arrival times were presented. Therefore, no experiment 2a could be held with these respondents, since that experiment involves variation in the most likely arrival time.

3. THE SAMPLE COLLECTED FOR FREIGHT TRANSPORT

Shipper and carrier firms were recruited from existing registers of firms (amongst others from the Chamber of Commerce) and approached (mostly by phone) to seek firms that were prepared to participate in the interviews. Within the firm, we searched for the director or head of logistics or operations (at carrier firms) or head of distribution (shippers).

The subsequent interviews were carried out as face-to-face interviews where a professional interviewer visited the firm and the questions were shown on a laptop computer.

Table 3 shows the number of respondents for each of the questionnaire types (by means of different colours – see below) and for each mode. With 812 successfully completed interviews, this survey is, together with the recent Norwegian VoT survey (Halse et al., 2010), one of the largest SP surveys ever carried out in freight transport.

The data were checked for outliers and implausible combinations of attribute values. As a result, we excluded 88 respondents from further analysis.

Discrete choice models were estimated on the SP data of the remaining 724 interviews. Annex 1 presents the key statistics for the resulting sample.

Table 2: Number of freight respondents by (sub)segment

		Road	Rail	Air	Inland water-ways	Sea	Total
Container	Carrier	35	10	0	16	18	**79**
	Own account shipper	10	2	0	0	0	**12**
	Contract out shipper	41	14	0	18	80	**153**
Non-container	Carrier	131	5	19	69	12	**236**
	Own account shipper	36	0	0	0	0	**36**
	Contract out shipper	162	19	44	22	49	**296**
Total		**415**	**50**	**63**	**125**	**159**	**812**

Note: the questionnaire types are indicated by a shading colour:

(light blue)	Questionnaire type A – carrier (road, rail, air)
(orange)	Questionnaire type B – shipper that contracts out (all modes)
(yellow)	Questionnaire type C – own account shipper (road, rail, air)
(light green)	Questionnaire type D – inland waterways and sea transport carriers

4. THE ANALYSIS OF THE DATA FOR FREIGHT TRANSPORT

We estimated separate SP models for carriers and shippers and for container and non-container. Own account shippers were combined with carriers because initial estimations showed that no acceptable separate models for own account shippers could be estimated, and combining them with carriers gave better results than combining them with contract out shippers. For carriers, we estimated separate models by mode. For road carriers, these models were further segmented by shipment weight class.

We tried several specifications of the utility function. The first specification was a linear utility function in willingness-to-pay (WTP) space. This means that the VOT and VOR are estimated directly, as single coefficients, instead of calculated as the ratio of the estimated time (or reliability) and cost coefficients. This gives for the utility U:

$$U = \beta_C \cdot (C + VOT \cdot T + VOR \cdot \sigma) + e \qquad [1]$$

where:

- β_C = cost coefficient
- C = transport cost
- T = transport time
- σ = standard deviation of the transport time distribution
- e = disturbance term (i.i.d, extreme value type I)

The second specification that we tried was the multinomial logit model in log-willingness-to-pay (logWTP) space (Fosgerau and Bierlaire, 2009). This specification was successfully used in the recent Danish, Norwegian and Sweden VOT surveys in passenger transport (e.g. Fosgerau, 2006; Börjesson and Eliasson, 2011; Börjesson et al., 2011). In a mean-standard deviation model this gives for utility U:

$$U = \lambda \cdot \log\left(C + VOT \cdot T + VOR \cdot \sigma\right) + e \qquad [2]$$

where:

λ = scale parameter

Finally, we tried a relative model specification, in which the attributes are measured relative to the observed (base) levels, which differ over respondents. So, the utility of a fractional change of each attribute is estimated. However, this cannot be done for the scheduling terms (early and late), since it is not sensible to define a fraction of an arrival time.[4] The relative mean-standard deviation model (using MNL) is:

$$U = \beta_C^{rel} \cdot \frac{C}{C_0} + \beta_T^{rel} \cdot \frac{T}{T_0} + \beta_R^{rel} \cdot \frac{\sigma}{\sigma_0} + e \qquad [3]$$

where:

C_0 = Current value of the transport cost, which is equal to the base value of cost in the SP experiments(BaseCost)

T_0 = Base value of the transport time, which is equal to the base value of time in the SP experiments (BaseTime)

σ_0 = Base value of the standard deviation of the transport time distribution in the SP experiments (this value comes from the SP design, since the degree of unreliability was not based on observed unreliability, but varies with observed travel time).

Relative models were also used (for all the modes) in the Dutch freight VOT studies of 1992 (Hague Consulting Group et al., 1992) and 2003/2004 (RAND Europe et al., 2004) to cope with the heterogeneity in the typical transports in the SP data.

Other specifications such as the scheduling model, have been tried as well, to see which specification performs best on the data obtained. If a scheduling model did a better job in explaining the data, it would still be possible, under certain conditions, to calculate a standard deviation of transport time from the estimated scheduling coefficients (Fosgerau and Karlström, 2010).

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[4] A fraction of a deviation from a desired arrival time could, however, be included, if the initial deviation was not equal to zero. But for transports that arrive at the most desired moment, this would imply division by zero.

The specification that worked best for carriers in road transport was the multinomial logit model in log-willingness-to-pay (logWTP) space (equation [2]).

Estimation results are given in Table 3 (the full set of estimation results can be found in Significance et al. 2012b). We report on a mean-standard deviation model here (see equation [2]). To correct for repeated measurements (we have up to 19 choice situations per respondent), we used the Jackknife method. The table shows the results after this Jackknife procedure was completed.

Table 3: Estimated coefficients and t-ratios (in brackets) for MNL logWTP model for carriers and own account shippers in road transport

Segment	Road – container Truck 2 -40 tonnes Jack-knife		Road – non-container Truck 2 - 15 tonnes Jack-knife		Road – non-container Truck 15 - 40 tonnes Jack-knife	
Observations		612		1170		900
Respondents		34		65		50
Final log (L)		-347.0		-683.6		-517.6
D.O.F.		2		3		2
Rho²(0)		0.182		0.156		0.170
	Value	(T-ratio)	Value	(T-ratio)	Value	(T-ratio)
Lambda (Cost)	-11.69	(-6.3)	-8.747	(-6.2)	-10.79	(-6.7)
VOT	45.97	(3.2)	18.49	(2.6)	36.87	(3.3)
VOR			29.62	(2.6)		
			Derived value			
Reliability ratio			1.60	(1.8)		

Note:

- Lambda is the scale parameter
- VOT is the monetary value of a change of one hour in transport time, in Euro per movement.
- VOR is the monetary value of a change of an hour in the standard deviation of transport time, in Euro per movement

In Table 3 we see that the VOT estimate is significant for all road carrier segments. For the first and last road carrier segments, the VOR was not significantly different from zero; it is only significant for the 2-15 tonnes segment.

For the non-road models and all models for shippers the relative specification (equation [3]) performed best. A possible explanation why the relative model works best for these segments but not for road (where a logWTP model in absolute values worked best) is that the observed degree of heterogeneity of the transports is clearly larger in these segments compared to road transport (this can be seen by looking at the weight or cost in Annex 1). The estimation results for the relative models are presented in Table 4 (see Significance et al. (2012b) for the full set of estimation results).

Table 4: Estimated coefficients and t-ratios (in brackets) for relative MNL models

Segment	Rail – Jack-knife		Air – Jack-knife	
Observations	306		324	
Respondents	17		18	
Final log (L)	-157.7		-205.3	
D.O.F.	2		2	
Rho²(0)	0.257		0.086	
	Value	(T-ratio)	Value	(T-ratio)
BetaCost (relative)	-9.742	(-4.6)	-4.533	(-3.0)
BetaTime (relative)	-3.157	(-2.6)	-2.830	(-3.0)
	Derived value		Derived value	
Trade-off ratio time vs cost	0.324	(3.3)	0.624	(3.1)

Segment	Inland waterways - Waiting for lock/bridge – Jack-knife		Inland waterways - Waiting for lock/bridge – Jack-knife		Sea – waiting for a quay – Jack-knife	
Observations	432		480		336	
Respondents	36		40		28	
Final log (L)	-251.1		-308.7		-212.0	
D.O.F.	3		3		3	
Rho²(0)	0.162		0.072		0.090	
	Value	(T-ratio)	Value	(T-ratio)	Value	(T-ratio)
BetaCost (relative)	-5.952	(-3.4)	-22.75	(-3.9)	-4.829	(-3.2)
BetaTime (relative)	-5.709	(-7.2)	-2.840	(-4.1)	-2.716	(-2.8)
	Derived value		Derived value		Derived value	
Trade-off ratio time vs cost	0.959	(4.6)	0.125	(4.5)	0.563	(3.1)

Segment	Shippers – Container – Jack-knife		Shippers – non-container – Jack-knife	
Observations		2520		4482
Respondents		140		249
Final log (L)		-1379.9		-2623.7
D.O.F.		4		5
Rho²(0)		0.210		0.155
	Value	(T-ratio)	Value	(T-ratio)
BetaCost (relative)	-10.19	(-11.5)	-6.992	(-13.1)
BetaTime (relative)	-2.043	(-3.2)	-0.706	(-2.7)
BetaRel (relative)	-0.629	(-4.2)	-0.634	(-5.7)
	Derived value		Derived value	
Trade-off ratio time vs cost	0.200	(3.4)	0.101	(2.8)
Trade-off ratio reliability vs cost	0.062	(4.5)	0.091	(6.6)

Time and cost are significant for all relative models, but reliability is only significant for shippers. For non-road transport operators, the coefficient on relative variability was not significantly different from zero.

Different characteristics of the shipment were tried as interaction variables (e.g. commodity type, value density), both for the relative models and for the logWTP models for carriers in road transport, but these did not provide a clear pattern, presumably due to the still limited number of observations. Models distinguishing between modes, container/non-container, shipment weight and shipper/carrier performed best.

The ratio of the estimated time coefficient to the estimated cost coefficient in a relative model can be treated as a '**trade-off ratio'** (TR), that indicates how relative changes in time are traded off against relative changes in costs.

$$\mathrm{TR} = \frac{\beta_{\mathrm{T}}^{\mathrm{rel}}}{\beta_{\mathrm{C}}^{\mathrm{rel}}} \qquad [4]$$

By multiplying this ratio by the transport cost per hour for a mode (or vehicle type within a mode), the so-called 'factor costs', we obtain the VOT (and similarly the VOR):

$$\mathrm{VOT} = \mathrm{TR} \cdot \mathrm{FactorCost} \qquad [5]$$

These factor costs were made available by the Ministry (NEA, 2011) and used in our project in combination with the new SP estimates.

More sophisticated models than the above, such as models that account for reference dependence (Kahneman and Tversky, 1992), or unobserved heterogeneity using mixed logit and latent class models[5], did not lead to stable results for freight transport. Despite the large sample, compared to most other SP surveys in freight transport, our sample is still too small for these more sophisticated models.

We could not estimate successful models on the relatively small sample that was obtained for RP choices.

5. DISCUSSION OF THE OUTCOMES FOR VOT AND VOR

5.1 SP outcomes for the VOT and comparison to previous values and the international literature

We added the carrier and shipper components from the estimation results of the 2010 SP models to calculate new VOTs (see Table 5) per vehicle and vessel, using external data on the factor cost in those cases where we estimated relative models. The main results for the VOT can be summarised as follows:

- The VOT is the sum of a transport cost component (about 80% on average) and a cargo component (about 20% on average; in Norway the latter component made up 14% (Halse et al., 2010)).
- The VOTs for road transport (about 5 euro per tonne) and rail transport (about 1.2 euro/tonne) are not very different from the 2004 study (after correcting for inflation) and consistent with the international literature (see the review by Feo-Valero et al., 2011).
- For inland waterway transport and sea transport we now obtain higher and more plausible values per hour than in 2003/2004: the value of time waiting for a bridge/lock is clearly worth more per unit than the 2004 VOT for total transport time.
- The trade-off ratio (TR) from the SP models is between 0.2 and 1.1, depending on the mode.

5.2 VOT in the short and long run

This last consideration raises the question why we should not assume that the trade-off ratios is always equal to 1, so that we only have to update the factor costs in the future to get the VOT. Before 1992, freight VOTs in The Netherlands had to be based on the factor cost and various assumptions were used regarding costs that should be included in the VOT: only the transport staff cost and the fuel costs (e.g. McKinsey, 1986) or all transport costs minus overheads (NEA, 1990).

Table 5: Values of time (Euro/hour per vehicle or vessel, price level 2010)

[5] The latter worked very well in this project for the passenger data (see Kouwenhoven et al., 2013).

	Road	Rail	Air	Inland waterways	Sea
Container	*[2-40t truck]:* 59	*[full train]:* 880	*Not applicable*	*[ship waiting for a quay]:* 98 *[ship waiting for a lock/bridge]:* 340	*[ship waiting for a quay]:* 760
Non-container	*[2-15t truck]:* 23 *[15-40t truck]:* 44 *[all non-container]:* 37	*[bulk]:* 1200 *[wagonload train]:* 1100 *[all non-container]:* 1200	*[full freighter aircraft]:* 13000	*[ship waiting for a quay]:* 65 *[ship waiting for a lock/bridge]:* 300	*[ship waiting for a quay]:* 830
All	*[2-40t truck]:* 38	*[full train]:* 1100	*[full freighter aircraft]:* 13000	*[ship waiting for a quay]:* 69 *[ship waiting for a lock/bridge]:* 300	*[ship waiting for a quay]:* 820

Notes:

- All these values are combined values from shippers and carriers and were obtained after rounding off.
- The values for rail are for a train (not a wagon).
- The values for inland waterways and sea refer to a ship.

An argument for not including fuel costs savings in the VOT is that most transport projects nowadays are carried out to reduce congestion, not to reduce transport distances: there are time gains, but the project does not change the transport distances (and even if a project leads to shorter routes, it may be better to evaluate these fuel costs benefits separately, as is done in the UK, and not include these through the time gains).

The reports on the first national Dutch freight value of time study (Hague Consulting Group, 1991, 1992) discuss the use of the factor cost method versus (SP and/or RP) models for obtaining values of time for use in CBA. In these reports it is argued that value of time research in freight transport needs to find the “time-marginal transport cost”: the transport costs that will change as a result of changes in transport time. This is the derivative of the total logistics cost function with respect to transport time (the standard marginal cost approach is about the derivative with respect to a unit of transport services, say measured in tonne-kilometres). The total logistics costs consists of transport staff cost (e.g. truck drivers), energy costs (e.g. diesel), vehicle costs, overhead costs (e.g. office space and administrative staff of the carrier firm), which are all cost that carriers incur, but also of the deterioration of the goods, the interest costs on the value of the goods during transport and the costs of having a reserve stock for safety (the last three items thus relating to the cargo component of the VOT).

The factor cost used to calculate the VOT in Table 5 and the transport cost in the SP only refer to the costs of the carriers (the transport costs). Therefore, when including the cargo component in the value of time, the trade-off ratio taken relative to the transport cost may in principle exceed 1. For most commodities however, deterioration, interest and safety stocks will be very limited.

Most of the trade-off ratios that we now find are substantially lower than 1. This means that the value of a time gain is considerably lower than the factor cost.

It is conceivable in practice that the trade-off ratio for transport time versus transport costs can be smaller than 1, because it may be difficult for firms to convert the time gains fully into cost reductions or additional revenues. The time gain for instance could, for instance, be too small to use for other transport activities, or additional work for a transport firm could only be realised against high costs (marketing, discounts), taking into account that the volume of transport services is not very price elastic (because the demand for transport largely depends on product markets). Furthermore, there are regulations concerning the opening times of firms at the origin and destination, driving and sailing times and labour contracts, that prevent full flexibility in using time gains productively for other transports or for reducing costs. In the longer run, which is the proper perspective for CBA of transport infrastructure, there will be more possibilities for re-organising logistics and therefore to reduce costs or increase output to benefit from time savings, and the trade-off ratio can be expected to be higher.

The imperfect flexibility (or kinked production function or cost function) argument could be more relevant for train, inland waterways and sea transport, since these modes have much larger indivisibilities (large vehicles and vessels that are used for trips that take a long time, possibly also with slot allocation). Also for the products transported using these modes, which generally have a lower value per tonne than products transported by road and air transport, the cargo component in the VOT will be relatively small.

Therefore, in the long run we expect that the trade-off ratio for road transport will not be far below 1. Those for other modes may be somewhat smaller, but in the long run these too should not be too far from 1 (in the 2004 SP for instance, the trade-off ratio for sea transport was 0.16, which is very likely too low to be credible).

From the current survey we now obtain a trade-off ratio (after weighting for the shares of container and non-container by mode) for road transport of 0.65, rail 0.46 and air 0.72 (the latter value is not significantly different from 1, though the others are). These values seem plausible, though the value for rail is rather at the low end. The TRs for inland waterways and sea transport come from very different SP experiments, and refer to a somewhat different setting:

that of waiting at a lock, bridge or quay. For these comparisons we have found TRs of 0.24 and 1.07 (inland waterways: quays and locks/bridges respectively) and 0.68 (maritime, quays). Here it seems prudent to take the average for the values for inland waterways, so that we obtain a value of 0.66 (for quays, locks and bridges), close to the quay value for sea transport.

A related question is whether Stated Preference is capable of providing the long run cost savings in freight transport that arise in case of time gains. In general, SP is more oriented to the short and medium run, because respondents may find it hard to imagine circumstances very different from the current situation, used to customise the SP experiment. In our freight VOT survey, we explain to the respondents just before the choice tasks 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. This should also make clear that the time savings do not only relate to the shipment that is being studied, but occur on a much wider scale. Carriers were told that a shorter transport time might be used for other transports: the staff and vehicles/vessels can be released for other productive activities and a higher reliability entails that the carrier can be more certain about such re-planning/re-scheduling. Shippers were asked to take into account what would happen (deterioration, disruption of production process, running out of stock, etc.) to the goods if the delivery were late. Nevertheless, respondents may still have difficulty including other logistics structures in their valuations of time and reliability and be reluctant to take a long run view. The TRs that we obtain should therefore be regarded as a lower boundary for the TR in the longer run. The upper boundary of the TR will be around 1.

5.3 SP outcomes for the VOR and comparison to previous values and international literature

The VOR (measured as the standard deviation of transport time) was calculated the same way as the VOT. The main outcomes (see Table 6) are:

- The VOR is mainly due to shippers (cargo-related); most carriers have no significant VOR.
- The RR is between 0.1 and 0.4, depending on the mode. This is substantially lower than the preliminary (highly provisional) value of 1.2 (for road transport) from de Jong et al. (2009); In the current survey, unreliability, its context and its consequences were made much more explicit and the presentation format is much more suitable for measuring unreliability in terms of the standard deviation of transport time (or scheduling terms).
- Other more recent empirical studies, notably Halse et al. (2010) and Fowkes (2006), have also found similar low RR in freight (when including carriers).
- The impact of just-in-time deliveries and perishable commodities on the VOR should be reflected in the shipper's component of the VOR. This

component is significant in estimation, but usually not very large in money terms. One might have expected higher values for this component to reflect the popularity of just-in-time in modern logistics thinking, but the results that we obtain should also take into account that time-critical segments are still a relatively minor part of all freight transport (unless we measure transport in terms of the value of the cargo shipped).

- The carrier component of the VOR has to do with the impact of reliability on being able to use vehicles and services for other transports. For this effect we find a coefficient that is not significantly different from zero (except for road non-container, 2-15 ton, which is the vehicle type most used for urban distribution, where transport times can be highly uncertain due to heavy congestion in cities). This could be due to the small samples that we had to use in estimation and therefore we have to be careful in interpreting and using these results. In principle carriers could take into account that they could lose customers if their transport reliability became worse, but in our freight SP experiments, the changes in reliability are presented explicitly as things that happen to all carriers, so there are no competitive advantages or disadvantages here.
- One possible reason for the rather low shipper VOR and the mostly insignificant carrier VOR[6] might be that the agents in freight transport are accustomed to thinking in terms of transport times, not in terms of variability. Their typical reaction to unreliability of travel times is to build in buffers (buffer times, buffer stocks, buffer staff, buffer equipment). The question is whether the respondents in the SP experiments only gave the direct impact of changes in variability or whether they included the knock-on benefits and costs of changes to the buffers. This can only be investigated by in-depth interviews with these agents (e.g. Krüger et al., 2013). The long-run values of variability might therefore be higher and the values from this SP research can perhaps best be regarded as a lower bound (conservative estimate).

[6] The relatively small monetary values that we find for reliability seem to contradict surveys among shippers that found that reliability is the most important non-cost factor in mode choice (e.g. NERA et al., 1997). These studies however usually compare reliability to scheduled time, not to expected time (as we do), which will be more relevant if this often deviates from scheduled time (and then some of the value of unreliability will transfer to the value of expected transport time). More generally, a ranking study that finds reliability at the top of the list of non-costs attributes provides considerably less information than a stated preference study that gives a value of unreliability in money or transport time equivalents.

Table 6: Values of reliability (Euro/hour per vehicle or vessel, price level 2010)

	Road	Rail	Air	Inland waterways	Sea
Container	*[2-40t truck]:* 4	*[full train]:* 100	*Not applicable*	*[ship waiting for a quay]:* 18 *[ship waiting for a lock/bridge]:* 27	*[ship waiting for a quay]:* 45
Non-container	*[2-15t truck]:* 34 *[15-40t truck]:* 6 *[all non-container]:* 15	*[bulk]:* 260 *[wagonload train]:* 240 *[all non-container]:* 250	*[full freighter aircraft]:* 1600	*[ship waiting for a quay]:* 25 *[ship waiting for a lock/bridge]:* 25	*[ship waiting for a quay]:* 110
All	*[2-40t truck]:* 14	*[full train]:* 200	*[full freighter aircraft]:* 1600	*[ship waiting for a quay]:* 24 *[ship waiting for a lock/bridge]:* 26	*[ship waiting for a quay]:* 100

Notes:
- All these values are combined values from shippers and carriers and were obtained after rounding off.
- The values for rail are for a train (not a wagon).
- The values for inland waterways and sea refer to a ship.

6. CONCLUSIONS

In The Netherlands, a project was completed to update the freight VOTs from a previous national freight study from 2003/2004. This new study collected SP data among shippers and carriers in 2010, using computerised personal interviews. We obtained a relatively large sample (812 interviews), but (probably) still too small for estimating more sophisticated models that account for unobserved heterogeneity. These models were successfully applied for passenger transport (Kouwenhoven et al. 2013).

This paper made several contributions to the literature. Two components in the VOT and VOR are distinguished: the transport cost and the cargo component. Specific instructions in the SP are given to shippers that contract out and to carriers so that their values of time and reliability will be the cargo component and the transport cost (vehicles, staff) component respectively and become additive. For all shippers and the carriers in road, rail and air transport the SP experiments included transport costs and usual door-to-door transport time, as well as a series of five equi-probable transport times with corresponding arrival times. The presentation of reliability in the form of five equi-probable transport with a departure time and corresponding arrival times is new in freight transport.

VORs were estimated in the form of a standard deviation of transport time, which has been uncommon in freight transport, but has the advantage that it can relatively easily be included in forecasting models. A new SP context was developed for carriers in sea and inland waterway transport, i.e. that of waiting at a bridge/lock or quay. This led to higher VOTs for waiting time than for overall transport time as it was estimated in 2003/2004. The data set used is possibly the largest SP survey carried out in freight transport to date (in terms of number of interviews). Several model specifications have been tested on the same data, including models in preference and (log) willingness to pay-space, scheduling models as well as mean-dispersion models and relative MNL models. New values of time and reliability were presented for The Netherlands (which other countries can use for comparison, benchmarking or even value transfer) and a comparison was made with the existing literature.

We find that for the VOT the transport cost (carrier) component is considerably more important than the cargo (shipper that contracts out) component, whereas for the VOR the cargo component is small but positive and the transport cost component for most segments not significantly different from zero.

The models that performed best were logWTP models for carriers in road transport and relative MNL models for all other carriers and the shippers (that need to be combined with an external estimate of the factor cost, or transport cost per hour).

The resulting VOTs for road and rail are not very different from those of 2003/2004. These values are also compatible with the international literature. The reliability ratios (RRs) that we obtain for the importance of reliability (measured as the standard deviation) relative to transport time are between 0.1 – 0.4, in line with recent empirical studies abroad, but lower than in earlier assessments.

Respondents in the SP survey may have had difficulty including other logistics structures and changes in buffers in their valuations of time and reliability and may have found it hard to take a long run view. The trade-off ratios that we obtain from the SP should therefore be regarded as a lower boundary for the trade-off in the longer run. The upper boundary will be around 1, implying that the VOT should approximately be equal to the transport costs per hour.

In order to include both time and reliability benefits in freight transport in the CBA of transport projects in The Netherlands, one also needs to include reliability in the freight transport forecasting models and be able to predict the impact of transport projects on reliability. This is a topic that requires further research.

REFERENCES

Börjesson, M. and J. Eliasson (2011) Experiences from the Swedish value of time study, CTS working paper, Centre for Transport Studies, Royal Institute of Technology, Stockholm.

Börjesson, M., J. Eliasson and J.P. Franklin (2011) Valuation of travel time variability in scheduling versus mean-variance models, Centre for Transport Studies, Royal Institute of Technology, Stockholm.

Bradley M.A. and A.J. Daly (1992) Stated preference surveys, In: E.S. Ampt, A.J. Richardson and A.H. Meyburg (Eds.): *Selected Readings in Transport Survey Methodology,* Eucalyptus Press, Melbourne.

Carrion, C. and D. Levinson (2012) Value of travel time reliability: A review of current evidence, *Transportation Research A,* 46, 720-741.

Cirillo, C., A.J. Daly and K. Lindveld (2000) Eliminating bias due to the repeated measurements problem, in J. de D. Ortúzar (Ed.): *Stated Preference Modelling Techniques*, PTRC, London.

Feo-Valero, M., L. Garcia-Menendez and R. Garrido-Hidalgo (2011) Valuing freight transport time using transport demand modelling: a bibliographical review, *Transport Reviews*, 201, 1-27.

Fosgerau (2006) Investigating the distribution of the value of travel time savings, *Transportation Research Part B*, 40 (8), 688-707.

Fosgerau, M. and Bierlaire, M. (2009) Discrete choice models with multiplicative error terms. *Transportation Research Part B,* 43 (5), 494-505.

Fosgerau, M. and Karlström, A. (2010) The value of reliability, *Transportation Research Part B*, 44(1), 38-49.

Fowkes, A.S. (2006) The design and interpretation of freight stated preference experiments seeking to elicit behavioural valuations of journey attributes, ITS, University of Leeds.

Hague Consulting Group, Rotterdam Transport Centre and NIPO (1991) De reistijdwaardering in het goederenvervoer, eindrapport voorstudie, Rapport voor Rijkswaterstaat, Dienst Verkeerskunde, HCG, Den Haag.

Hague Consulting Group, Rotterdam Transport Centre and NIPO (1992) De reistijdwaardering in het goederenvervoer, rapport hoofdonderzoek, Rapport 142-1 voor Rijkswaterstaat, Dienst Verkeerskunde, HCG, Den Haag.

Halse, A., H. Samstad, M. Killi, S. Flügel and F. Ramjerdi (2010) Valuation of freight transport time and reliability (in Norwegian), TØI report 1083/2010, Oslo.

Hamer, R., G.C. De Jong, and E.P Kroes. (2005) The value of reliability in Transport – Provisional values for the Netherlands based on expert opinion, RAND Technical Report Series, TR-240-AVV, Netherlands.

HEATCO (2006) Developing Harmonised European Approaches for Transport Costing and Project Assessment, Deliverable 5, Proposal for harmonized guidelines. IER, University of Stuttgart.

Jong, G.C. de (2008) Value of freight travel-time savings, revised and extended chapter in: D.A. Hensher and K.J. Button (Eds.): *Handbook of Transport Modelling,* Handbooks in Transport, Volume 1, Elsevier.

Jong, G.C. de, M. Kouwenhoven, E.P. Kroes, P. Rietveld and P. Warffemius (2009) Preliminary monetary values for the reliability of travel times in freight transport, in *European Journal of Transport and Infrastructure Research,* Issue 9(2), pp. 83-99.

Kahneman, D. and A. Tversky (1992) Advances in prospect theory: Cumulative representation of uncertainty, *Journal of Risk and Uncertainty*, 5 (4), 297-323.

Kouwenhoven, M., G.C. de Jong, P. Koster, V. van den Berg, Y.Y Tseng, E. Verhoef, J. Bates and P. Warffemius (2013) Values of time and reliability in passenger transport in The Netherlands, Significance, The Hague.

Krüger, N., I. Vierth, G.C. de Jong, A. Halse and M. Killi (2013**)** Value of freight time variability reductions, Results from a pilot study for the Swedish Transport Administration, VTI, Stockholm.

McKinsey (1986) Afrekenen met files, McKinsey & Company, Amsterdam.

NEA (1990) Rekening Rijden en het goederenvervoer over de weg, Rapport 90183/12526, NEA, Rijswijk.

NEA (2011) Kostenbarometer goederenvervoer, rapport voor DVS, NEA, Zoetermeer.

NERA, MVA, STM and ITS Leeds (1997) The potential for rail freight, A report for the Office of the Rail Regulator, ORR, London.

RAND Europe (2004) De Waardering van kwaliteit en betrouwbaarheid in personen- en goederen vervoer (The valuation of quality and reliability in passenger and freight transport). AVV/RAND Europe, Rotterdam.

RAND Europe, SEO and Veldkamp/NIPO (2004) Hoofdonderzoek naar de reistijdwaardering in het goederenvervoer, rapport TR-154-AVV voor AVV, RAND Europe, Leiden.

Significance, VU University Amsterdam and John Bates (2007) The value of travel time and travel time reliability, Survey design, Final Report prepared for the Netherlands Ministry of Transport, Public Works and Water Management, Significance. Leiden.

Significance, Goudappel Coffeng and NEA (2012a) Erfassung des Indikators Zuverlässigkeit des Verkehrsablaufs im Bewertungsverfahren der Bundesverkehrswegeplanung: Schlussbericht, Report for BMVBS, Significance, The Hague (see: http://www.bmvbs.de/SharedDocs/DE/Artikel/UI/bundesverkehrswegeplan-2015-methodische-weiterentwicklung-und-forschungsvorhaben.html).

Significance, VU University, John Bates Services, TNO, NEA, TNS NIPO and PanelClix (2012b) Values of time and reliability in passenger and freight transport in The Netherlands, Report for the Ministry of Infrastructure and the Environment, Significance, The Hague.

Small, K.A. (1982) The Scheduling of Consumer Activities: Work Trips, *American Economic Review*, 72, 467-479.

Vickrey, W. (1969) Congestion Theory and Transport Investment, *American Economic Review*, 59 (2), 251-261.

Tseng, Y.Y., E.T. Verhoef, G.C. de Jong, M. Kouwenhoven and A.I.J.M. van der Hoorn (2009) A pilot study into the perception of unreliability of travel times using in-depth interviews, *Journal of Choice Modelling*, 2(1), 8-28.

Zamparini, L. and A. Reggiani (2007) Freight transport and the value of travel time savings: a meta-analysis of empirical studies, *Transport Reviews*, 27-5, 621-636.

Annex 1. Descriptive statistics of the estimation sample (time in minutes, cost in Euros and weight in tonnes)

		Carriers										Shippers	
		Road					**Rail**	**Air**	**Inl.waterw.**		**Sea**	**All modes**	
		Container		Non-container			All	All			Quay		
		0-2t	*2-40t*	*0-2t*	*2-15t*	*15-40t*			Quai	Lock / bridge		Cont.	Non-cont.
BaseTime	min	35	15	15	30	15	150	150	10	60	60	65	30
	max	480	2010	2880	6660	6300	10800	6360	1320	5940	2160	128610	59550
	median	60	180	80	165	150	2880	1650	60	480	75	15195	240
	average	139	336	382	464	424	3277	2318	127	1153	267	23613	1770
	stdev	191	453	783	947	988	2762	2155	211	1536	431	25714	4792
BaseCost	min	19	58	12	40	30	105	300	200	20	50	1	10
	max	450	1750	1300	2200	2000	23000	12000	34000	5545	250000	80000	50000
	median	60	271	85	350	310	1800	1750	2000	131	5000	1113	250
	average	143	415	185	479	404	4867	3431	3495	446	34243	3087	1587
	stdev	179	376	248	442	375	6600	3751	5402	1094	70224	8709	6029
Weight	min	0.02	2.5	0.01	2.5	18	5	0	100	28	0	1	0
	max	2	30	2	15	37	1680	10	25000	8000	85000	650	20000
	median	1	20	0.5	8	24.5	20	0.80	1000	1400	2000	18	3
	average	0.9	17	0.7	8	26	265	2.6	2057	1821	7541	40	182
	stdev	0.9	8.3	0.6	4	5	570	3.3	3958	1525	17143	103	1356

Annex 2. Attribute values presented in the SP experiments

Time attribute levels – Road transports

BaseTime (min.)	**Time level** *(relative to base)* **Freight by road**				
	level -2	*level -1*	*level 0*	*level 1*	*level 2*
10 – 19	-3	-1	0	2	5
20 – 44	-5	-2	0	3	8
45 – 74	-10	-5	0	5	15
75 – 119	-15	-5	0	10	25
120 – 179	-15	-10	0	10	30
180 – 239	-20	-10	0	15	40
240 – 359	-40	-20	0	20	60
360 – 539	-60	-30	0	30	90
540 – 1439	-120	-60	0	60	180
1440 – 2879	-240	-120	0	120	360
2880 +	-480	-240	0	240	720

Time attribute levels – All transports except road, inland waterways and sea

BaseTime (min.)	**Time level** *(relative to base)* **Freight other**				
	level -2	*level -1*	*level 0*	*level 1*	*level 2*
10 – 59	-5	-2	0	5	10
60 – 179	-15	-10	0	10	30
180 – 599	-40	-20	0	30	60
600 – 1439	-120	-60	0	90	180
1440 – 2159	-240	-120	0	180	360
2160 – 2879	-360	-180	0	270	540
2880 – 4319	-480	-240	0	360	720
4320 – 5759	-720	-360	0	540	1080
5760 – 10079	-960	-480	0	720	1440
10080 +	-1920	-960	0	1440	2880

Cost attribute levels – All transports except inland waterways and sea

Cost level *(relative)* **FREIGHT**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-15%	-5%	0%	+10%	+25%

Reliability attribute levels – Road transports

Reliability *(relative to time level)*				
Base time: 10 – 19 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-2	-2	-2	-2	-2
0	0	0	0	0
0	0	0	0	0
0	2	4	7	7
2	5	8	15	20

Base time: 20 – 44 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-5	-5	-5	-5	-5
0	0	0	0	0
0	0	0	0	0
0	5	10	15	15
5	10	20	30	40

Base time: 45 – 74 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-10	-10	-10	-10	-10
0	0	0	0	0
0	0	0	0	0
0	10	20	30	30
10	20	40	60	80

Base time: 75 – 119 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-15	-15	-15	-15	-15
0	0	0	0	0
0	0	0	0	0
0	15	30	45	45
15	30	60	90	120

Base time: 120 – 179 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-20	-20	-20	-20	-20
0	0	0	0	0
0	0	0	0	0
0	20	40	60	60
20	40	80	120	160

Base time: 180 – 239 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-30	-30	-30	-30	-30
0	0	0	0	0
0	0	0	0	0
0	30	60	90	90
30	60	120	180	240

Base time: 240 – 359 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-40	-40	-40	-40	-40
0	0	0	0	0
0	0	0	0	0
0	40	80	120	120
40	80	160	240	320

Base time: 360 – 539 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-60	-60	-60	-60	-60
0	0	0	0	0
0	0	0	0	0
0	60	120	180	180
60	120	240	360	480

Base time: 540 – 1439 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-90	-90	-90	-90	-90
0	0	0	0	0
0	0	0	0	0
0	90	180	270	270
90	180	360	540	720

Base time: 1440 – 2879 min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-240	-240	-240	-240	-240
0	0	0	0	0
0	0	0	0	0
0	240	480	720	720
240	480	960	1440	1920

Base time: 2880+ min. Road				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-480	-480	-480	-480	-480
0	0	0	0	0
0	0	0	0	0
0	480	960	1440	1440
480	960	1920	2880	3820

Reliability attribute levels – All transports except road, inland waterways and sea

Reliability *(relative to time level)*				
Base time: 10 – 59 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-2	-2	-2	-2	-2
0	0	0	0	0
0	0	0	0	0
0	2	4	7	7
2	5	8	15	20

Base time: 60 – 179 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-10	-10	-10	-10	-10
0	0	0	0	0
0	0	0	0	0
0	10	20	30	30
10	20	40	60	80

Base time: 180 – 599 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-30	-30	-30	-30	-30
0	0	0	0	0
0	0	0	0	0
0	30	60	90	90
30	60	120	180	240

Base time: 600 – 1439 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-90	-90	-90	-90	-90
0	0	0	0	0
0	0	0	0	0
0	90	180	270	270
90	180	360	540	720

Base time: 1440 – 2159 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-240	-240	-240	-240	-240
0	0	0	0	0
0	0	0	0	0
0	240	480	720	720
240	480	960	1440	1920

Base time: 2160– 2879 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-360	-360	-360	-360	-360
0	0	0	0	0
0	0	0	0	0
0	360	720	1080	1080
360	720	1440	1920	2880

Base time: 2880 – 4319 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-480	-480	-480	-480	-480
0	0	0	0	0
0	0	0	0	0
0	480	960	1440	1440
480	960	1920	2880	3840

Base time: 4320 – 5759 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-720	-720	-720	-720	-720
0	0	0	0	0
0	0	0	0	0
0	720	1440	1920	1920
720	1440	2880	3840	5760

Base time: 5760 – 10079 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-960	-960	-960	-960	-960
0	0	0	0	0
0	0	0	0	0
0	960	1920	2880	2880
960	1920	3840	5760	7640

Base time: 10080 min. Other				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
-1920	-1920	-1920	-1920	-1920
0	0	0	0	0
0	0	0	0	0
0	1920	3840	5760	5760
1920	3840	7680	11520	15280

Arrival time attribute levels –Road transport

BaseTime	Preferred Arrival Time level *(relative to base)* Freight by road				
(min.)	*level -2*	*level -1*	*level 0*	*level 1*	*level 2*
10 – 19	-3	-1	0	2	5
20 – 44	-5	-2	0	3	8
45 – 74	-10	-5	0	5	15
75 – 119	-15	-5	0	10	25
120 – 179	-15	-10	0	10	30
180 – 239	-20	-10	0	15	40
240 – 359	-40	-20	0	20	60
360 – 539	-60	-30	0	30	90
540 – 1439	-120	-60	0	60	180
1440 – 2879	-240	-120	0	120	360
2880 +	-480	-240	0	240	720

Arrival time attribute levels – All transports except road, inland waterways and sea

BaseTime	Preferred Arrival Time level *(relative to base)* Freight other				
(min.)	*level -2*	*level -1*	*level 0*	*level 1*	*level 2*
10 – 59	0	0	0	0	0
60 – 179	-3	-1	0	2	5
180 – 599	-10	-5	0	5	15
600 – 1439	-20	-10	0	15	40
1440 – 2879	-120	-60	0	60	180
2880 – 5759	-240	-120	0	120	360
5760 – 10079	-480	-240	0	240	720
10080 +	-960	-480	0	480	1440

Attribute levels – Inland Waterways and Sea Transport

Notes:

- All numbers below are multiplicative factors on the BaseWaitTime, presented wait time, total transport costs and cost for use of the quay, loading and unloading.
- The following minimum BaseWaitTimes apply
  - If experiment for bridge & BaseWaitTime < 10 min.then BaseWaitTime = 10 min.
  - If experiment for lock & BaseWaitTime < 15 min.then BaseWaitTime = 15 min.
  - If experiment for quay & BaseWaitTime < 60 min.then BaseWaitTime = 60 min.

A. Experiment for locks and bridges

Wait time level *(factor on BaseWaitTime)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.6	0.85	1.0	1.2	1.4

Total transport Cost *(BaseCost)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.94	0.98	1.0	1.02	1.05

Reliability *(factor on Wait time as presented)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.95	0.9	0.75	0.65	0.6
1.0	0.95	0.9	0.75	0.65
1.0	1.0	1.0	1.0	0.75
1.0	1.05	1.1	1.25	1.0
1.05	1.1	1.25	1.35	2.0

B. Experiment for quays/port terminals

Wait time level *(factor on observed)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.6	0.85	1.0	1.2	1.4

Cost for quay, (un)loading *(factor on observed)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.70	0.90	1.0	1.15	1.25

Reliability *(factor on presented wait time)* **IWW and sea transport**				
Level -2	*Level -1*	*Level 0*	*Level 1*	*Level 2*
0.95	0.9	0.75	0.65	0.6
1.0	0.95	0.9	0.75	0.65
1.0	1.0	1.0	1.0	0.75
1.0	1.05	1.1	1.25	1.0
1.05	1.1	1.25	1.35	2.0