VALUE-OF-TIME IN FREIGHT TRANSPORT IN THE NETHERLANDS FROM STATED PREFERENCE ANALYSIS

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INTRODUCTION

In applying monetary evaluation methods of infrastructural projects and other policy measures in transportation, travel time gains and losses are converted into money units, using a value-of-time.

For converting time savings and losses in passenger travel in The Netherlands, measures from the Dutch 'Value-of-Time Study' can be used. This study was undertaken by Hague Consulting Group for the Transportation and Traffic Research Division of Rijkswaterstaat of the Dutch Ministry of Transport (HCG, 1990).

Currently Hague Consulting Group is involved in applied research into the value-of-time in freight transportation in The Netherlands, with contributions and advice coming from the Rotterdam Transport Centre of Erasmus University Rotterdam and Steer Davies Gleave. The client again is the Transportation and Traffic research Division. This study was preceeded by a feasibility study which was concluded in June 1991. The main study started in autumn 1991 and is expected to conclude in the first half of 1992.

1. Methodology in general

For establishing value-of-time measures in freight transport, several methods can be used. First there is a distinction between *factor cost methods* and methods using *models for choices in freight transport.*

The factor cost method basically consists of two steps. Firstly, to calculate the costs made in the transport of goods. Costs items which should be included here are:

- labour costs
- fixed and variable costs of the mode used in transport
- decrease in the value of goods in transport and interest on the inventory in transit.

Secondly, to determine which of these items in the costs functions of carriers and shippers change if the travel times change (and to which extent).

Figure 1 shows a classification of models for the choice of mode in freight transport (other choices can be used as well).

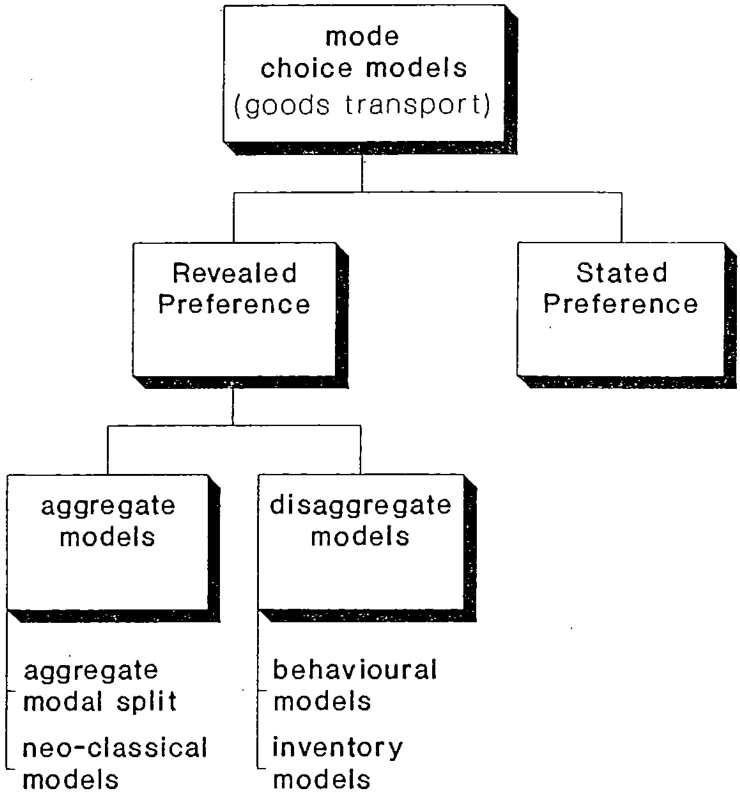

Figure 1. Models for the mode choice in freight transport

The existing models for the choice of mode in freight transportation can be classified in a number of ways. Here we adopt a classification which starts with the distinction between 'Revealed Preference' (RP) models and 'Stated Preference' (SP) models. As in the models for the passenger mode choice, RP models use data on observed behaviour, while in SP models the data are statements of individual respondents about their preferences in hypothetical choice sets. The crucial difference between RP and SP therefore is not the model structure, but the nature of the data which are being used. For RP modal choice models, observed transport mode choices are used; In SP modal choice models, the researcher defines transport alternatives and individuals are asked to choose among those or to give their preferences.

Within RP models we distinguish aggregate models, where the units of observation are aggregates of decision-makers, and disaggregate models, where the unit of observation is the decision-maker, the actor. In aggregate models the observations are mostly for regions within a country. As a result, valuable information on the specific context of the consignments is lost; the cases in disaggregate freight mode choice are for individual firms or managers. Only a few such databases exist.

In Figure 1 there are two types of aggregate models: the aggregate modal split models (or: aggregate logit models, e.g. Blauwens and Van de Voorde, 1988) and the neo-classical aggregate models (e.g. Oum, 1989). The first type of models is not based on behavioural theory; the mode share in the transport of a commodity between two regions is explained here by using characteristics of transport between the regions by different modes (and possibly also by using other characteristics of the regions or of the goods). The neo-classical aggregate models on the other hand are based on cost-minimizing behaviour of firms according to the neo-classical economic theory of the firm.

Within the disaggregate models there are also two distinct types of models: behavioural models (e.g. Winston, 1981) and inventory models (e.g. Chiang, Roberts and Ben-Akiva, 1981; McFadden, Winston and Boersch-Supan, 1985). In the first type the emphasis is on the single mode choice decision; in the second the mode choice decision is studied in connection with other decisions the firm has to take, especially within the larger framework of inventory and logistic policy.

Stated Preference models are primarily relevant in the calibration of disaggregate models. SP data has some advantages in the case of freight modelling, in particular as it may be possible to obtain data (for example on costs and rates) which would be difficult to acquire by other methods (also see Fowkes, Nash and Tweddle, 1991). The drawback of SP data is its hypothetical nature: these are stated responses to hypothetical choices, not actual decisions. This problem can be minimised using carefully designed SP surveys in which the respondents are asked to choose between alternatives relevant to their own circumstances (Contextual Stated Preference). In computer-based Stated Preference experiments decision-makers, such as logistics managers, can be presented with the choice between alternatives for a specific consignment. The alternatives are defined using previous answers from these respondents. This method offers a high degree of flexibility, capable of dealing with the heterogeneity of freight transport.

2. Methodology for the main study

The choice of methodology for the main study was based on:

- an analysis of relevant literature
- data availability
- advice from expert meetings
- experience from an SP pilot (5 case studies).

The recommended methods were:

- factor cost method (to provide reference levels)
- Contextual Stated Preference
- disaggregate inventory models or Strategic Stated Preference for the long run value-of-time.

In the Contextual Stated Preference (CSP) experiment the choice-alternatives are within-mode options for a typical transport, selected by the shipper or carrier himself. The value-of-time results from this are interpreted as short to medium term outcomes. In the long run firms can respond to travel time changes by adapting their mode choice, depot size and location, production location, technology, etc. For assessing these more strategic issues, inventory models or another type of SP, called Strategic SP, can be used. In Strategic SP, respondents are asked to trade between general structural time gains and losses on the one hand and changes in the total costs (e.g. through taxation) on the other hand.

In consultation with the Dutch Ministry of Transport, the following choice for the methodology for the main study was made:

- factor cost method
- Contextual Stated Preference
- Strategic Stated Preference.

3. Segmentation

The Dutch freight value-of-time study concerns all transport within The Netherlands (including the domestic parts of international transport) using the modes:

- road transport
- rail transport
- inland waterways transport.

For road transport, four segments are used to establish value-of-time differences between broad categories of firms:

A: low value raw materials and semi-finished goods
B: high value raw materials and semi-finished goods
C: finished goods with loss of value (e.g. perishable goods)
D: finished goods, no loss of value.

No segmentation is made for rail and inland waterway transport, due to the limited number of observations in the SP interviews. It is noted that almost all rail and inland waterway transport is in segment A.

4. Preliminary factor cost results

At the current phase of the study, it is provisionally assumed that the total transport cost per hour are set equal to the value of one hour of travel time. Later on, decisions must be made whether all transport cost items should be included in the value-of-time and whether other (logistic) costs should be added to this.

For road and inland waterway transport, the transport costs were calculated by combining the characteristics of freight transport by these modes in The Netherlands, according to statistics compiled by the Dutch Central Bureau of Statistics (CBS), with cost pricing rules from NEA reports (NEA, 1988, 1989). These costs include some 'profit margin', through interest on capital invested.

For rail, cost information was not available, since the NS (Dutch Railways) regard this as confidential information. Here we used the official rates for wagon loads as a starting point.

Travel time is defined as door-to-door travel time, including transhipment time as long as this is not incurred at the origin and the destination ends of the shipment.

Table 1 contains the preliminary freight value-of-time measures from the factor cost method. Their primary function is to serve as reference levels for the SP work. These values are per shipment; for road transport they apply to a truck, for rail to a complete train (not to a wagon) and for inland waterways they are for an average ship.

5. Preliminary results from Contextual Stated Preference

119 Contextual SP interviews were conducted in two waves, during November 1991 and January 1992, among shippers and carriers by the NIPO. The interviews used the MINT software, developed by HCG. The respondents were director or owner of the firm or the logistics, distribution or sales manager. The response rate was rather high:

Table 1. Preliminary factor cost results: value per shipment per hour, in 1988 guilders

Segment:	value-of-time
road, raw or semi-finished, low value	59
road, raw or semi-finished, high value	62
road, finished, loss of value	61
road, finished, no loss of value	62
rail	1359
inland waterways	292

76%. In the interviews the respondents were asked to choose between alternatives for a typical transport they were involved in. The attributes of these alternatives were

- transport costs or rates
- travel time
- travel time reliability
- probability of damage (for most cases)
- frequency of shipment (for other cases).

The attribute levels are the ones given by the respondents before, and percentual deviations from these reference levels (e.g. costs +20%).

Appendix 1 is an example of a screen in the MINT-interview, containing two alternatives.

Each respondent was involved in one or two SP experiments, depending on the actual modal split of the firm. If the firm used rail, ship and road for freight transport, it was first asked to choose a typical rail transport and participate in the rail experiment and next to choose a typical transport by ship for the ship experiment. All experiments were 'within mode'; the choice set consisted of alternatives referring to one particular mode. If the firm used ship and road, the respondent was invited to do the SP games for ship and road. We did not ask for participation in more than two games for fear of fatigue among the respondents, which might affect the reliability of the answers (the interviews lasted 30-45 minutes). Rail was given priority over ship and ship over road in order to obtain enough observations for the less likely modes rail and ship. The composition of the sample is given in Table 2.

Table 2. Composition of the Contextual Stated Preference sample.

respondents	number of interviews	number of experiments:					
		rail	ship	road A	road B	road C	road D
shippers	75	7	8	21	20	15	16
carriers	44	3	16	2	3	6	13
total	119	10	24	23	23	21	29

For the definition of the road transport segments A-D, see section 3. In total the 119 interviews gave 130 CSP 'within mode' experiments.

The results of these interviews were used to estimate *linear ranking regression models* and *logit models*. Linear regression models are not really appropriate for qualitative dependent variables, such as rankings. On the other hand, in practice they often have been providing reasonable results. Logit models of course are especially designed for handling qualitative dependent variables.

The ranking regression models were estimated per respondent, while the logit models were estimated on the pairwise choices per segment. The explanatory variables in both cases are the percentual differences between the attribute levels and the (actual) base-alternative attribute level. Models with absolute changes were also tried, but proved to be of lower statistical quality (t-ratio's, pseudo-R^2) than the models in percentual changes. The estimation results, obtained using the ALOGIT programme (as developed by HCG), for the logit models are shown in Table 3.

The ratio of the time coefficient to the cost coefficient indicates how some percentual change in travel time is traded off against a percentual change in transport costs. By applying this ratio to the hourly transport cost (as derived from the factor cost analysis, which is our primary source for actual cost information) estimates for the value-of-time are obtained. Another option would have been to calculate the trade-off, not per shipment, but per ton. This value could then be applied to the factor cost per ton. The value-of-time per shipment in this case would be the value per ton times the shipment tonnage. This option was not chosen because transportion costs are not directly proportional to shipment weight. Transporting a 20 ton shipment is not 10 times as expensive as a shipment of 2 ton, but say only twice as expensive.

Table 3. Estimation results for logit models on CSP data (t-values in brackets)

variable segment	costs or rates	travel time	probability of damage	% not delivered on time	frequency
road A	-.080 (11.1)	-.082 (9.2)	-.055 (7.8)	-.052 (6.4)	.013 (2.4)
road B	-.069 (10.5)	-.074 (9.2)	-.043 (7.9)	-.034 (4.5)	.016 (2.8)
road C	-.087 (11.6)	-.082 (9.7)	-.044 (6.4)	-.041 (5.0)	.014 (2.3)
road D	-.096 (13.6)	-.080 (11.)	-.046 (7.5)	-.062 (8.2)	.006 (.9)
rail	-.072 (7.2)	-.063 (5.5)	-.025 (4.0)	-.060 (6.4)	.003 (.3)
ship	-.059 (11.1)	-.072 (11.)	-.038 (7.2)	-.035 (6.0)	.011 (1.4)

The results for the value-of-time in the transport of goods, obtained through logit models and ranking regression models, are listed in Table 4. For the ranking regressions we use the ratio of the average time and costs coefficients in a segment.

Table 4. Preliminary freight value-of-time results from logit models and ranking regressions on CSP data. Value per shipment per hour, in 1988 guilders.

Segment	logit models per segment	ranking regressions
road, raw or semi-finished, low value	61	62
road, raw or semi-finished, high value	67	66
road, finished, loss of value	57	52
road, finished, no loss of value	51	48
rail	1201	1182
inland waterways	356	378

The resemblance between the value-of-time outcomes from both model types is striking. We prefer to use the logit outcomes because that model is better suited to the kind of data analysed here (as was discussed above). Furthermore, in the logit model the data are used in their original form (pairwise choices), whereas the rankings are derived from series of pairwise choices from the same respondent.

The first four freight value-of-time measures (for road) can be compared to the value-of-time results for personal travel (HCG, 1990). Here the SP value-of-time for car drivers (also in 1988 guilders per hour) is 13 guilders for home to work travel, 11 guilders for 'other travel' and 51 guilders for business travel (the latter also including the valuation of the employer). The weighted average for all 4 road segments for freight is 57 guilders. The value-of-time for a truck turns out to be higher than those for a passenger car (with only a driver); somewhat higher than for business travel, much higher than for all other travel.

The CSP value-of-time for transporting raw materials and semi-finished goods by road (weighted average of 63 guilders) is higher than the value for finished products (weighted average of 52 guilders). This can be explained by the fact that raw materials and semi-finished products need further processing. Delays during transport may cause delays in the production process, with all subsequent costs. Similar, but more qualitative, results were found by INRO-TNO in a study on behavioural changes of companies as a result of time-delays in road traffic (INRO-TNO, 1991).

As was expected, the value-of-time is higher for finished products with the potential for loss of value (fruit, meat, flowers) than for finished products without loss of value. The premium for this risk is almost 12% of the value-of-time for the latter commodity.

The values for rail and inland waterways again are for a complete train and ship respectively. The ratio of the time coeficient to the cost coefficient is 0.884 for rail and 1.220 for inland waterways. These ratios may seem high compared to those for road transport (close to 1). However, one must bear in mind that a 10% change in travel time for road transport on average is a couple of minutes, while a 10% change for rail and ship is on average more than an hour.

In the CSP questionnaire some screening questions have been included to select firms for the Strategic SP experiment. The purpose here is to select firms which are making strategic decisions. Sufficient firms, interviewed in the CSP data collection effort, seem to be making strategic choices in the presence of large structural travel time changes. SSP will be carried out amongst a selection of these firms.

6. Summary and conclusion

Value-of-time measures are needed as an input in monetary evaluation studies for formulating transportation policy. In this study, two methods for establishing value-of-time measures in freight transport have been applied in The Netherlands. Firstly, the transport costs of an hour were calculated. The results of this can be used independently or in conjunction with the second method. Secondly, in interviews shippers and carriers were given the choice between hypothetical alternatives for a typical transport, with attribute levels based on the actual levels (Contextual Stated Preference). Logit models estimated on these CSP data indicate how a percentual change in time is traded off against a percentual cost change. These trade-off ratios were applied to the transport cost of an hour, as derived from the first method. The freight value-of-time results from both methods are of the same magnitude. On average, shippers and carriers are almost indifferent between some percentual change in travel time and the same percentual change in transport costs or rates. For a truck, the hourly value-of-time (from CSP) is 57 guilders, which is four to five times the value found for a person driving a passenger car for non-business purposes.

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Appendix 1. An example of a screen with two choice-alternatives in the MINT-interview for the freight value-of-time study

<< Which alternative do you prefer? >> Q. C-1

OPTION A	OPTION B
Transport cost is 300 guilders. (= the SAME as now)	Transport cost becomes 240 guilders. (= 20% LOWER)
Percentage cheese shipments NOT on time is 5 %. (= the SAME as now)	Percentage cheese shipments NOT on time becomes 8 %. (= 50% HIGHER)
Travel time becomes 1 hour 25 min. (= 15% LOWER)	Travel time becomes 1 hour 40 min. (= the SAME as now)
Probability of damage in transit is 10 promille. (= the SAME as now)	Probability of damage in transit is 10 promille. (= the SAME as now)

1 Definitely A   2 Probably A   3 Not sure   4 Probably B   5 Definitely B