Evaluation of Some Important Quality Parameters in Long-distance Goods Transport
- results from a stated preference analysis

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"Transportkvalitetens indflydelse på overflytning af gods til bane og søtransport" is a study commissioned by Transportrådet. The aim of the study is to determine and further evaluate a number of parameters of quality of goods transport in the long distance goods transport from both transport buyers and transport producers point of view. The obtained results are to be used in a simulation model. The study will be finished by the end of the year.

This paper summarises both the applied methodology and the intermediate results from the Stated Preference (SP) analysis part of the study. The aim of this part of the study is to evaluate the chosen quality parameters. The evaluation is based on three types of information: Rating (revealed preference observations), Ranking (revealed preference observations), and Stated preference (hypothetical) observations.

1. Introduction

Danger of air and noise pollution, and number of traffic accidents raises dramatically with the presence of more and more trucks on the European roads. It is predicted that in 2010, 84% of the total goods transport in the 15 EU countries will be carried on roads in relation to only 49% in 1970 and 70% in 1992. At the same time, rail and sea transport are predicted to carry only 5% each of the total goods transport in the EU member states in 2010, compared to 32% and 12% in 1970 and 16% and 8% in 1992, respectively (source: EU Commission 1996).

To shift more goods from road to rail and sea in the future, it is crucial to understand better the importance of different parameters of quality of goods transport, which determine, both on their own but also when acting together, modal split in the European goods transport. An analysis of these quality parameters might have a rather broad meaning. In that context, one can search for answers of the following questions: What is quality? How can quality be defined in goods transport? What are the most important quality parameters? Do they differ in importance in different parts of the transport chain? Can we compare numerically quality parameters? How can these parameters be implemented into the mode choice models?

This part of the "Transportkvalitetens indflydelse på overflytning af gods til bane og søtransport" study concentrates on a numerical evaluation of eight pre-chosen quality parameters. Two types of analysis exist in the study:
1. rating and ranking, based on the revealed preference information, and
2. stated preference analysis, based on hypothetical observations.

Rating and ranking information are drawn from the respondents present transport policies. It is observed how important the chosen quality parameters are (rating), for transport buyers (i.e., producers of goods and trading companies) and transport producers (i.e., freight forwarders and shippers). The sample is therefore divided into two segments in this part of the study. Further, we observe differences in ranking of the quality parameters in order of importance in the two segments.

Stated preference information are used in the model context. In-mode SP data are completed from five SP games (i.e., a number of SP questions in a row), distinguishing levels of changes among the parameters for road, rail and sea transport. As a result, three models are developed with the estimates for the chosen quality parameters. Based on that monetary values of each of the quality parameters for the three modes of transport are obtained. That gives us the most sensible information for comparing different parameters of quality of goods transport for each of the modes.

2. Sample and The Questionnaire

The sample

It has been planned to complete 140 interviews with both transport buyers and transport producers, covering all major parts of Denmark. Further, we have been interested in getting information from users of road, rail/combined and sea transport. Finally, only long-distance transports (more than 300 km) with all commodity groups are sampled.

This paper summarises the first results based on 60 SP interviews completed in the period from March 18, 1996 till April 15, 1996. The rest of the planned interviews will be completed in the August-September period, mainly in Jylland. Geographically, 45 companies in the sample are located on Sjælland and 15 companies are located on Fyn. Further, 25 companies are buyers of transport services and 35 companies are producers of transport services. The distribution of the interviews for commodity groups is in accordance to the NST/R classification (source: Atkins, 1991). Respondents reported the *'main commodity',* i.e. the commodity type that has been transported the most, in terms of tons transported, in the last 12 months. Another commodity group could be used when describing a particular freight journey from origin to destination, which is input for the SP games. The sample contains 5 rail/combined transport companies, 19 sea and 36 road transport companies.

One more source of data has been used for the purposes of this study. This is 115 SP interviews completed in 1993 (source: Jovicic G., 1994). In-mode SP data from this source are applied in the model structure for each of the three modes separately. The sample was again distributed among transport buyers and transport producers situated mainly on Sjælland and in Jylland, transporting all types of commodities. Fifty-two of the interviewed companies in this sample are defined as road transport companies, 39 as rail/combined transport companies and finally 24 as sea transport companies.

The questionnaire

Managers of the transport planning departments or logistic departments of the companies were involved in the computer based interviews. Therefore, the accuracy of the data is achieved from a few angels:

- the most reliable persons are interviewed, i.e. persons who take decisions in transport planning in their companies,
- respondents are successfully branched through the questionnaire, i.e. they answered only questions relevant to them,
- all the answers are saved automatically and also processed automatically, i.e. we diminished number of errors in the final data matrixes, but also saved time and money, compared to the manual input of data.

Based on the research from other individuals and companies involved in the project it has been decided to do an investigation of a limited number of parameters of quality of goods transport. The chosen parameters are evaluated for transports on distances of minimum 300 km between the origin and the destination because for shorter distances the modal split is limited, to a great extent, to road transport only. The research is focused on the following eight parameters of quality of long-distance goods transport:

1. transport time,
2. reliability,
3. risk of damage,
4. transport price,
5. frequency of transport,
6. information system,
7. flexibility, and
8. customer service.

3. Results

Based on the presently applied transport policies (i.e., revealed preference (RP) data) for transports longer than 300 km, the respondents were involved in rating and ranking exercises. The whole sample is divided, for this purpose, among transport buyers and producers of transport services. It is important to notice here that these RP data are not related to any specific shipment when talking about transport producers (e.g., specific commodity group, specific value and weight of the shipment, specific transport distance, etc.). Rather than that, it was searched for more general perception of the chosen quality parameters (e.g., the most recently done transport, a transport of the most usual type of commodity). The following tables in paragraphs 3.1 and 3.2 should therefore be understood as a very general presentation of understanding of the quality parameters, i.e. the picture would be different for a specific commodity group and type of transport.

The respondents were later in the questionnaire involved into the hypothetical questions, i.e. stated preference games. These data have been used for modelling purposes. Models for road, rail and sea transport give therefore estimates for the quality parameters that can be used in their monetary evaluation. An example for a rail company is given in paragraph 3.3. Differences in ranking of the parameters from the RP and SP data are to be expected because the RP data are related to a general perceptions of the parameters regardless of transport mode, while the SP data is related for a specific shipment and transport mode.

3.1 Rating

Depending of the segment to which the respondent belongs (i.e., transport buyer or transport producer) each of the eight quality parameters were defined appropriately (source: NTU, 1996) and shown on the computer screen. After that, the respondent was asked to rate each of the eight parameters of quality of goods transport in the scale of five degrees of impedance. To calculate the mean values of the parameters it is assumed that each of the points are represented by a *'class interval'* and a '*middle point of the class'*, as shown in table 3.1.1.

Table 3.1.1 - Rating scale, class intervals and the middle points

Scale	**Class interval**	**Middle points**
Extremely important	0 - 2	1
Very important	2 - 4	3
Important	4 - 6	5
Not important	6 - 8	7
Not important at all	8 - 10	9

Twenty-five of the interviewed companies are understood as transport buyers and 35 as producers of transport services. The calculated mean values for the two segments are shown in table 3.1.2. Obviously, the chosen quality parameters are considered to be at least *'very important'* factors in the present transport policies of both producers and buyers of transport services.

3.1.2 - Calculated mean values for the two segments

Variable	**Transport buyers**		**Transport producers**	
	Mean value	**Importance**	**Mean value**	**Importance**
Transport time	2,84	very important	3,51	very important
Reliability	1,64	extremely important	2,14	very important
Risk of damage	3,08	very important	3,06	very important
Transport cost	3,24	very important	2,94	very important
Transport frequency	3,00	very important	2,51	very important
Information system	2,68	very important	3,46	very important
Flexibility	3,40	very important	3,97	very important
Customer service	3,00	very important	2,54	very important

3.2 Ranking

In the second part of the questionnaire the respondents were asked to rank the eight quality parameters in order of importance based on their own perception. That means that they were asked to imagine the most general transport for their company, if belonging to transport producers. For the order of importance from 1 to 8 we attached a number of points from 10 to 3 (e.g., the parameter ranked as the most important gets the maximum of 10 points, the second one 9, etc.). The calculated mean values have given to us therefore the order of importance of the chosen quality parameters in the two segments. The results are shown in tables 3.2.1 and 3.2.2.

Table 3.2.1 - Ranking results for **buyers** of transport services

Rank	**Variable**	**Mean value**
1	Reliability	8,6
1	Transport time	8,6
3	Transport cost	7,0
4	Customer service	6,1
5	Flexibility	5,7
6	Risk of damage	5,6
7	Information system	5,4
8	Transport frequency	5,1

Table 3.2.2 - Ranking results for **producers** of transport services

Rank	**Variable**	**Mean value**
1	Reliability	8,5
2	Transport cost	7,9
3	Transport time	7,8
4	Customer service	6,8
5	Flexibility	5,6
6	Transport frequency	5,57
7	Risk of damage	5,1
8	Information system	4,9

The three most important quality parameters among the chosen parameters, that all are rated to be at least *'very important'* in the transport policies of the interviewed companies, are 'reliability' (i.e., risk of been delayed at the destination), 'transport time' and 'transport cost', regardless of the segments. In the second group we might include 'customer service' and 'flexibility'. Finally, in the last group we might include 'risk of damage', 'information system' and 'transport frequency'. Shuffling among the parameters inside the groups occurs.

3.3 Stated preference analysis

Data from the previous study of combined transport has been joined to the data from the new SP interviews. Only in-mode SP data have been used from both studies. This presumably helps us to achieve more realistic estimation values of the investigated parameters. There are no theoretical obstacles in joining data from different sources. In-mode SP data are ideal for evaluation purposes because: correlation between the parameters is eliminated (SP data), and choice of mode is not present in the data (i.e., alternatives are typically named as 'Alternative 1' and 'Alternative 2'). This helps the respondents to concentrate on the parameters' values only when choosing the best among the alternatives.

'Customer service' was not included in the SP games because it couldn't be described independently of other parameters like transport time and/or flexibility. Road, rail and sea transport modes are modelled separately. The estimates are shown as well as the t-values. Further, we show monetary values of the investigated parameters of quality of goods transport for each of the models.

Model for road transport

The estimation of the model for road transport is based on a set of 2315 stated preference observations. The first 487 observations are completed in the new study while 1828 observations are taken from the old study. Transport time, transport cost, risk of damage and delay are common variables in both studies. Flexibility and information system are variables specific to the new study. The estimation results and t-values of the parameters in the model are shown in table 3.3.1.

Table 3.3.1 - Parameter estimates in the model for road transport

Parameters	Flexibility	Time	Cost	Damage	Delay	Information System
Estimate	0.4497	-0.06489	-0.00063	-0.06127	-0.3280	0.5645
T-value	3.4	-9.2	-8.9	-8.1	-11.2	2.6

Model for rail transport

The model estimation is based on a set of 917 stated preference observations. The first 93 observations are completed in the new study while 824 observations are taken from the old study. Transport time, transport cost, frequency and risk of delay are common variables in both studies. Risk of damage, flexibility and information system are variables specific to the new study. Table 3.3.2 shows the estimation results and t-values in the model.

Table 3.3.2 - Parameter estimates in the model for rail transport

Parameters	Flexibility	Time	Cost	Damage	Delay	Information System	Frequency
Estimate	1.274	-.0444	-.1796e-2	-1.080	-0.1199	2.240	0.6411
T-value	3.2	-5.9	-9.8	-3.8	-5.7	3.5	13.3

Model for sea transport

The model estimation is based on a set of 1339 stated preference observations. The first 242 observations are completed in the new study while 1097 observations are taken from the old study. Transport time, transport cost, frequency and risk of delay are common variables in both studies. Risk of damage, flexibility and information system are variables specific to the new study. The estimation results and t-values of the parameters in the model are shown in table 3.3.3. Notice that 'flexibility' is not estimated significantly different from zero, due to the insufficient number of observations.

Table 3.3.3 - Parameter estimates in the model for sea transport

Parameters	Flexibility	Time	Cost	Damage	Delay	Information System	Frequency
Estimate	0.2018	-.802e-2	-.533e-3	-.9114	-0.222	0.7184	0.2469
T-value	1.2	-7.3	-8.3	-4.9	-7.8	2.4	8.3

Validation of the models

Estimates of the chosen parameters of quality of goods transport do not show much on their own. One can, however, observe from the estimates if a particular parameter is estimated with the correct sign. For example, transport time should have a minus sign meaning that longer transport time makes that alternative less attractive. Secondly, t-value of a particular variable, which is its estimate divided by the standard error, gives information of how 'trustful' an estimate is (i.e., significantly different from zero). Typically, for a 95% confidence level t-value is greater than 1,96 in absolute value. All the estimates in the models have the correct sign and they are significantly different from zero. An exception to that is 'flexibility' in the 'sea' model, that has the correct sign but it is not significantly different from zero.

The most convenient way of comparing the estimates inside one model and/or between the models is to do a validation of the model(s). This means, that monetary values of each of the parameters of quality of goods transport in the three models should be found, for example. This is typically done by dividing the obtained estimates of transport time, damage, delay, frequency, flexibility and information system with the obtained estimate of transport cost, in the models. Table 3.3.4 compares values of the parameters of quality of goods transport between the models. To understand better the following table we first need to describe units and levels of the parameters.

Transport Time: *hours*
Transport Cost: *dkr*
Risk of Damage: *per mille (per thousand)*
Risk of Delay: *per cent*
Frequency: *number of departures per week*
Flexibility: ***Level 1** - There is no changing of the previously agreed transport*
***Level 2** - Shipment's weight and delivering time can always change*
Information System: ***Level 1**: - Only information about the shipment at the destination*
***Level 2**: - Information about the shipment always available. Automatic handling of the documentation*

Table 3.3.4: Monetary validation of the models (in dkr)

Parameters of Quality of Goods Transport	**Model for road transport**	**Model for rail transport**	**Model for sea transport**
Transport time	102,77	24,70	15,04
Risk of Damage	97,04	601,34	1708,66
Risk of Delay	519,48	66,76	416,76
Frequency	- - -	356,96	462,88

Flexibility	712,23	709,35	not significant
Information System	894,04	1247,22	1346,83

Discussion of the results
It is not possible to obtain a modal split from tables 3.3.1 to 3.3.4. For that purpose it is necessary to develop a mode choice model - we must add RP data as well as across-mode SP data. However, it is possible to see from table 3.3.4 how reasonable the obtained results are. To support the following discussion we will use the information from the sample's data. Modal description of the most important variables is given in table 3.3.5.

Table 3.3.5 - Average values for the chosen variables from the RP data

Variable	**Road Transport**	**Rail Transport**	**Sea transport**
Travel Distance (km)	798,70	1074,04	4835,95
Shipments Value (dkr/kg)	49,50	24,31	19,81
Shipments Weight (tons)	12,56	18,98	161,28
Travel Time (hours)	28,85	61,73	243,86
Driving Time (hours)	13,50	30,86	243,86
Average Driving Speed (km/hr)	61,44	34,79	19,83
Travel Cost (dkr)	6458,10	9129,11	27398,25
Risk of Damage (per mille)	6,15	9,31	7,53
Risk of Delay (per cent)	2,59	4,27	3,67
Travel Frequency	---	2,80	2,49

<u>Travel time:</u> Value of travel time is the highest for road transport (103 dkr/hr). Rail transport's value of time is 4 times smaller than for lorry transport while sea transport has the lowest value of transport time (15 dkr/hr).

This is in accordance with the knowledge that more expensive goods (i.e., high value commodities, small shipments on shorter distances, etc.) are usually transported on roads while 'cheaper' goods (i.e., low value commodities, large shipments on longer distances, etc.) are usually transported on rail and sea. In our sample, the smallest shipments (12,6 tons) with the highest value (50 dkr/kg) are transported on roads at the shortest distances (800 km) On the opposite side, we have got that the largest shipments (161 tons) with the lowest value (20 dkr/kg) are transported on sea at the longest distances (5000 km).

It is interesting to observe here that the average speed for road transport is about two times higher than the average speed for rail transport. Further, rail transport is about twice as fast as sea transport. Driving time for lorries is calculated from the total door-to-door transport time. For that purpose we have used the regulations about the driving and resting hours for truck drivers valid for the EU member countries (source: Danske Vognmænd, 1996). For rail transport driving time is assumed to be 50 per cent of the door-to-door transport time (source: TetraPlan Aps., 1996).

<u>Risk of damage:</u> The value of risk of damage for rail transport is six times higher in rail transport than in road transport. There are two possible explanations for this. One is, that damage of goods occurs much more frequently (i.e., 50 per cent more) in rail than in road transport. The other is, that the shipment's weight in rail transport, in average, is 50 per cent higher than in road transport. Apparently, when reporting the risk of damage the

respondents keep in their minds the weight of the shipment. We can also assume that the reported risk of damage is related to the number of parcels in the shipment, but these information are not available to us.

The value of risk of damage in sea transport is 17 times higher than in road transport. Here, we can clearly see the connection between the difference of the calculated values of risk of damage on one side and the observed damages and the shipments weight on the other side. Damage of goods occurs 1,22 times more frequently in sea transport than in road transport. Shipment's weight in sea transport, in average, is 12,84 times higher than in road transport. When multiplying the last two figures we get 15,66 which is very close to the calculated difference of value of damage between these two modes.

Risk of delay: Values of risk of delay are related to the type of transport (see discussion about transport time). Apparently, rail users are not willing to pay much for improvement of this parameter because low value goods are transported with low speed on very long distances.

Value of risk of delay for sea transport is close to that for road transport (20 per cent lower). This might be explained by a fact that some of our 'sea' data describe so called *feeder transport,* where it is very important to be on time in the main harbour.

Frequency of transport: Values of transport frequency are calculated for rail and sea transport only. Users of sea transport are willing to pay more for improvements of transport frequency based on the fact that we observed in the sample fewer weekly departures for sea transport than for rail transport.

Flexibility and Information system: These two parameters are different in nature from the previous ones. 'Flexibility' and 'Information System' are discrete variables, with 1/2 values, that are described through their levels. Calculated values for flexibility for road and rail transport are very close one to another.

Values of 'Information system' for slow modes are greater than for road transport. We can defend this based on the average travel times, i.e. road transport takes in average one day (sample value), while rail transport takes 2,5 days and sea transport takes 10 days. It is reasonable to assume that on longer transports the information system is more valuable.

How to compare obtained values for different parameters for one mode?
Each of the seven parameters presented in table 3.3.4 has different units. For example, value of time has a unit in **dkr/hour** while value of frequency has a unit in **dkr/number of departures per week**. In order to compare them it is necessary to obtain an uniform unit, which in our case is **dkr**. For this purpose we must know the average values for all variables for a specific mode. Further, we should know weekly/annual number of shipments for distances longer than 300 km. Improvement of the average values of the parameters on the annual base will give us possible savings, in dkr, for each parameter.

Let us take an example of a railway company. We will take the average values for all parameters from the sample (i.e., RP data). Further, we will assume the weekly number of shipments for distances longer than 300 km to be 100. Table 3.3.6 shows the obtained results.

Table 3.3.6 - Example for a railway company

Parameters	Monetary value	Average values	Assumed	Annual value of

	of the parameters per shipment (Model for rail transport)	of the parameters in the sample	weekly number of shipments	the parameters
Transport Time	24,70 (dkr/hour) per shipment	61,73 hours	100	7.928.601 dkr
Transport Cost	1 (dkr/dkr) per shipment	9129,11 dkr	100	47.471.372 dkr
Risk of Damage	601,34 (dkr/per mille) per shipment	9,31 per mille	100	29.112.072 dkr
Risk of Delay	66,76 (dkr/per cent) per shipment	4,27 per cent	100	1.482.339 dkr
Frequency	356,96 (dkr/weekly departure) per shipment	2,8 departures per week	100	5.197.338 dkr
Flexibility	709,35 (dkr/level) per shipment	1	100	3.688.620 dkr
Information System	1247,22 (dkr/level) per shipment	1	100	6.485.544 dkr
Total				101.365.886 dkr

(Example: Annual Value of Transport Time (AVTT)
AVTT = 24,70 dkr/hr/shipm. * 61,73 hr * 100 shipm./week * 52 weeks = 7.928.601 dkr)

Based on the results from the previous table it is possible to make a percentage valuation (in order of importance) of all seven quality parameters. This is shown in table 3.3.7.

Table 3.3.7 - Percentage validation of the parameters

Rank	**Variable**	**Percentage Value**
1	Transport Cost	46,83 %
2	Risk of Damage	28,72 %
3	Transport Time	7,82 %
4	Information System	6,40 %
5	Transport Frequency	5,13 %
6	Flexibility	3,64 %
7	Risk of Delay	1,46 %
	Total	100 %

Obviously, 'transport cost' is the most important of the chosen parameters for the railway company, for this type of analysis. When including the importance of 'risk of damage' to that, almost 80 % of the total importance, i.e. the sum of all the quality parameters, is described. In the group of the parameters of secondary importance it might be included 'transport time', 'information system' and 'transport frequency' with almost 20 % of the total importance. 'Flexibility' and 'risk of delay' are of the smallest importance here, according to the obtained results. The results have been evaluated externally. Apart of the concern related to the importance of reliability they are very well accepted. For very specific average values of the parameters, instead for our own estimates, the final results would be of even better quality.

4. Conclusion

Eight parameters of quality of long-distance goods transport are evaluated in the study. Information about the present transport policies (RP data) and the hypothetical situations (SP data) are collected from both transport buyers and producers of transport services in the sample of 60 companies. For the modelling purposes of the study, an additional set of SP data is applied from an earlier study.

All the parameters are rated to be *'very important'* in the present transport policies in both segments. Exception to that is 'reliability', which is rated to be *'extremely important'* for buyers of transport services. Seen generally and not from a specific transport point of view, 'reliability', 'transport cost' and 'transport time' are ranked the highest from both transport producers and transport buyers point of view. In the second group we include 'customer service' and 'flexibility'. 'Risk of damage', 'information system' and 'transport frequency' are in the group of parameters ranked the lowest in the two segments.

A numerical evaluation of the chosen quality parameters, all but 'customer service', is done for three transport modes separately. For that purpose within mode SP data has been applied. This type of data proved to be the most suitable for this kind of tasks. It is shown in paragraph 3.3, how we can gradually expand from estimates, that are difficult to be understood on their own, to the monetary values of the parameters and further to rank the quality parameters for a specific mode. In the example for a railway company, 'transport cost' is far the most important among the parameters explaining just about 50 % of the total importance of all the parameters. 'Risk of damage' explains another 30 % of the remaining importance. 'Transport time', 'information system' and 'transport frequency' are of secondary importance compared to the previous parameters. Finally, 'flexibility' and 'risk of delay' (reliability) are of minor importance to the customers when improving the service of this railway company. The results are well accepted in an external validation. Data from the additional set of 80 interviews, that will be completed soon, will improve the accuracy of the estimates.

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