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SPECIAL ISSUE: Freight transport analysis and intermodality

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From Trasporti Europei to European Transport \ Trasporti Europei

The first issue of Trasporti Europei was published in 1995, almost 10 years ago. The first issues were bilingual with a predominance of articles written in Italian. Gradually the Journal hosted a larger number of articles written in English by international scholars. The Journal was gaining a place in the international literature. It was time for a change. Starting from this issue, all articles will be in English. To mark this decision, the Journal's name has been changed to European Transport \ Trasporti Europei and its mission re-stated, combining national roots with international innovation.

European Transport \ Trasporti Europei is published three times a year by ISTIEE (Istituto per lo Studio dei Trasporti nell'Integrazione Economica Europea, Institute for the Study of Transport within the European Economic Integration, http://www.istiee.org/). ISTIEE is located in Trieste, Italy.

Given the Institute's mission, a special interest of the Journal is the role transport plays in promoting and facilitating European economic integration. The links between the Western and Eastern, Northern and Southern European countries will be receive special attention. However, these issues are not exhaustive and processes of integration in other geographical areas are also of interest to the Journal. The links between transport activities and economic development is another concern of the Journal. Both the mobility of passengers and freight is of interest, by any means of transportation. Issues such as intermodality, integration and interoperability, because of their importance, will be paid special attention to. Logistics and supply-chain management topics are also very relevant. Occasionally, special issues will be organised with the aim at collecting important contributions from prominent researchers on specific topics.

Transport topics will be approached from different perspectives. Economic, engineering and geographical aspects will be given particular emphasis. Although both theoretical, modelling and empirical papers will be published, a special emphasis will be given to the latter, with special reference to papers focusing on industry and market structure analysis, policy and institutional discussion as well as regulatory proposals. All papers or notes submitted for publication will be refereed and accepted solely on the basis of quality and importance with the aim at promoting and disseminating new ideas which can help improve the economic and environmental sustainability of the transport system.

Navigating for almost 10 years in the sea of international publications has proven a challenging but rewarding experience, thanks to the help and efforts of the many contributors which chose to submit their articles to Trasporti Europei. We hope that European Transport \ Trasporti Europei will have an even more gratifying navigation. This new phase of the Journal will take advantage of an enlarged group of distinguished international editors. The initial phase achieved in the past 10 years a number of important goals, thanks to the work of a group of young researchers, now well established in the profession, to whom goes the gratitude of the Institute.

Giacomo Borruso, Editor-in-chief

Romeo Danielis, Managing Editor

Special issue

Intermodal transport is the transport of unit loads by the combination of at least two modes of transport in a single transport chain. Goods are transported mainly by rail, inland waterways, or via ocean-going vessels, holding the possible initial and final journeys by road as short as possible. Due to environmental and congestion pressures this mode of transport has received increasing attention over the last few years. Indeed a review on external costs of intermodal transport compared to unimodal road transport (Kreutzberger, Macharis and Woxenius, 2004) showed that intermodal transport is more environmentally friendly than road transport.

Intermodal transport still satisfies only a limited amount of overall freight transport demand even if its modal share can be very large on specific lines or corridors. Intermodal transport is more and more seen as a competing alternative to unimodal road transport. Intermodal transport is also growing to a seamless door-to-door operation capable of working within a just-in-time framework.

Bontekoning, Macharis and Trip (2002), in a literature review of recent researches conducted in the area of intermodal transport showed that intermodal freight transportation research is emerging as a new research field of its own and, even if it still is in a pre-paradigmatic phase at the moment, it seams it is about time to move on to a more mature state.

Characteristics of a pre-paradigmatic phase, defined by the science philosopher Kuhn (Koningsveld, 1987) are: 1) several small research communities working on their own problems; 2) little references to other researchers (or only within the own research group); 3) lack of common problem definitions, hypothesis, definitions and concepts.

The situation will improve for the intermodal research field, intermodal practice and also for transport policy makers, when a distinct research community will materialise, held together by a consensus on definitions, concepts, problems to be investigated, and methodological coherence. Kuhn calls this the period of “normal science” in which research is conducted within the framework of a hypothetical paradigm.

Our nectar cluster on intermodal transport might constitute a small step towards the building up of a larger research community. We bring together several researchers from around Europe. This special issue is the product of one of our meetings. The cluster came to light in Helsinki in 2001 under the guidance of the cluster animators, Yvonne Bontekoning and Cathy Macharis. This cluster is part of the larger NECTAR network which is a scientific European network focused on transport, mobility and communications. In may 2002 the first “real” cluster meeting was held in Delft. A brainstorming workshop was held to define some guidelines, subjects of common interest for the group, such as, for example, the value of time, stated preference/conjoint analysis used in modal choice, cost analysis of intermodal/unimodal road transport, environmental issues and flow estimation modelling. During the second cluster meeting, held in Liège in November 2002, we focused on external costs of intermodal transport compared to road transport ones and invited speakers to share their knowledge on the subject. A joint paper of three of the cluster members was the result of this meeting. The meeting in Lugano, where we were kindly invited by Simona Bolis, was again a great success and this special issue reflects the quality of the papers presented and of the discussion. Our next plans are of course to partecipate to the next Nectar conference in Las Palmas this summer and to hold a new cluster meeting in Sweden later on.

The papers in this issue can be organised in three different groups.

A first, and most numerous, group deals, under different theoretical, methodological, and practial aspects, with service quality in intermodal freight transport (Danielis-Zotti, Marcucci-Scaccia, Bergantino-Bolis, Wiegmans-Rietveld-Nijkamp and Rudel). A second one is more focused on specific industrial policies for the improvement and development of intermodal trasnportation (Van Ham, Konings, and Kreutzberger) and a third group containing only one paper (Macharis) is aimed at the definition and illustration of a methodological innovation in the evaluation process of transport project implementation.

In more detail, the first group of papers deals with the issue of service quality in intermodal transportation. The methodology used is similar for four of the five papers in this group (Danielis-Zotti, Marcucci-Scaccia, Bergantino-Bolis, Rudel) where a stated preference, discrete choice modelling framework is used and a fifth one (Wiegmans-Rietveld-Nijkamp) adopts a more descriptive approach such as the SERVQUAL model.

Danielis and Zotti analyse, via a stated preference exercise, the likely effects of the introduction of transport policies aimed at stimulating the growth of intermodal transport. The studies scrutinise the situation of the mechanical sector in the Friuli – Venezia- Giulia region in Italy. After describing the sampling, data gathering and data base construction process the results of the estimation process are put forward. The service attributes that are studied in order to characterise service quality are, mode, cost, trip duration, frequency, flexibility and loss and damages. The models estimated are the multinomial logit, latent class model and random parameter logit. Thanks to the good quality of the data and of the interviews some interesting and significant results can be stated. As to the singular attributes of the transport service, cost and damages are the most important ones. Time reliability and trip duration are also important eventhough to a lesser extent and, maybe due to an unsatisfactory definition of frequency and flexibility these variables have not proven statistically significant.

Marcucci and Scaccia conducted a parallel research to that of Danielis and Zotti in the Marche region in Italy and concentrated on two industrial sectors: mechanics and furniture. The decision was taken in order to verify if there was a spatial influence in the two different regions (in both cases the mechanical sector has been examined) and also to test if there are substantially diverse preferences in different production sectors characterised by distinct logistic structures. The paper, using an extension of the traditional compensatory utility maximisation framework, studies the relevance of service quality in the process of mode choice in freight transport. The use of cutoff analysis can be traced back to the contribution of Swait (2001) even if it has never been applied to freight transport. The paper is innovative not only methodologically but also for the research field chosen. Starting with the description of the problem studied the paper accounts for the method of analysis employed as well as for the interviews and the data base collected and final comments on the results obtained. The most interesting results have to do with the specific reference to the sectorial analysis proposed. In fact, it is important to underline that there is a substantial difference between the furniture and mechanical sector testified by a lower attention paid to the attributes composing service quality in the mechanical sector with respect to the furniture one. A further characteristc differentiating these two sectors has to do with the different attitude towards cutoff compensability. Whereas freight transport demand is more flexible and compensation is possible even in presence of ex ante cutoffs (soft ones) in the mechanical sector the same is not true for the furniture one. The paper concludes that a rethinking of the present Italian freight transport policy, substantially based on train, ship and intermodality subsidisation, is needed.

Bergantino and Bolis try to empirically identify the factors which might exert a significant influence on the choice of operators given the growing interest towards a re-balancing of freight traffic over the different modes. The paper is characterised by three elements: a) it opts for an interactive approach which allows operators' preferences to be elicited on hypothetical alternatives; b) it restricts the modal choice to a maritime ro-ro service; c) focuses on freight-forwarders instead of producers. After describing the methodology used to assemble the dataset, the criteria followed in identifying the sample and the design of both the revealed preference survey and the adaptive stated preference experiment, a detailed description of the database and an illustration of the estimation procedure and main outcomes is presented along with a brief comparison of the main results with other EU studies. The main objective of the paper is the presentation of the preliminary evidence from a pilot study carried out with the primary objective of testing the validity of adaptive conjoint data collecting methods in analysing operators' preferences when redirecting current on-land transport services to a hypothetical maritime ro-ro alternative. Furthermore the paper has provided a preliminary rating of the transport attributes included in the stated preference experiment and a first on-the-field test of the soundness of the selection carried out with respect to the analysis of the maritime ro-ro context. Finally it has also tested the appropriateness of selecting freight forwarders as respondents in their vest of transport service users. The preliminary estimates suggest that in order to improve the use of the maritime ro/ro, maritime transport operators and institutional authorities should focus on actions improving the reliability and the frequency of service.

Rudel in his paper studies the evaluation of quality attributes in freight transport in Switzerland using a stated preference approach. The substantial increase of freight transport demand has recently been accompanied by structural changes demanding particular attention for lighter and more voluminous goods, generally shipped at higher frequency. New production concepts and spatial production networks have provoked a renewed interest for logistic services that have more and more been outsourced to specialized companies. At the same time new patterns in productive and distributive processes have generated a demand for high quality transport and logistic services. Empirical research on transport demand has mainly been focused on mode choice and travel time savings. However, no representative national analysis of travel time savings is available for Switzerland. Furthermore no other quality attributes, such as punctuality and avoidance of damages, has been researched. The filling of this gap tries to analyse and monetize the significance of quality attributes in the Swiss freight transport market. The research focuses on a specific freight market segment and, in spite of this limitation, produces a first important input for the building up of a cost-benefit analysis framework necessary for the evaluation of new infrastructure investments. The paper estimates the monetary values of the different quality attributes of transport services.

Wiegmans et al. investigate the role of service quality in the container terminal handling process. Service quality is scrutinised in order to understand how container carriers, having various options among different container ports in Europe, make their choice. A set of fourteen interviews is used to present an operational view on the judgment of service quality of container terminals by terminal operators. Interesting results, reported in the paper, are that, for maritime terminals, average delivery time is considered extremely important even if reliability is confirmed the number one quality aspect and, given the low demand elasticity, container handling price reductions will not stimulate container handling demand. As it is for continental terminals, single-mode transport is the reference point on which the terminal operators base their price. A critical performance condition for this terminal operators is a 'total service assortment' including pre- and end-haulage (logistics solution). Secondary services (container repair, cleaning, etc.) further increase sales. The competitive position of continental (mainly barge) terminals is stronger than that of maritime and rail terminals. In fact a large customer base and a broad service package offers good business opportunities. Short distance between the operating personnel and the management is also a crucial competitive issue.

The three papers dedicated more specifically to commercial and industrial policies to stimulate intermodal transport tackle, respecitively, the role of foldable container leasing, the feasibility of mega container vessels and the relevance that distance and time have from the shipper's point of view. The first two papers are strictly linked to maritime transport whereas the third one deals more specifically with road-rail intermodal transport.

Konings examine the role of conataniner lessors in boosting the introduction of foldable containers. Given that the shipping company fulfils a central role in the logistic chain of maritime container transport, it also has a substantial interest in limiting the costs of empty return transport. Various potential benefits of foldable containers under this respect are identified.

Leasing companies have always played an important role in the container industry, providing spot availability of containers throughout the world. Konings affirms that this role is confirmed by the balance of ownership of the world container fleet between shipping lines and leasing companies. The reluctance of carriers to invest in foldable containers is understandable, considering the financial burden of purchasing containers which can be three to four times the price of a standard box and a substantial number of boxes is required to reveal the system benefits of foldable containers. The foldable container has also to fit in the logistic process of the carriers in order to provide a real added value to them (see Konings & Thijs, 2001a). In addition to such logistic conditions, the technical and economic conditions are just as much of importance for their acceptance. The question of whether there are sufficient incentives for the container leasing industry to lead the way with foldable containers is open for discussion. The dramatic decline of new container prices in combination with low interest rates and the sharp decrease in utilisation rates, worsened by severe trade imbalances on the major trade routes, caused serious problems for the performance of the industry, both in terms of revenues and profitability. The trend towards consolidation in the container industry, the availability of more sophisticated and efficient financing techniques and better management of container imbalances world-wide by shipping lines suggest that ownership of containers by shipping lines will increase in the future at the cost of container leasing business (Stribley, 2000). A possible answer to this problem could be the broadening of lessors services beyond the traditional leasing functions of supplying standard equipment and finance.

Van Ham studies the role that the internationalisation and globalisation of economies has had on shipping due to the relevant quotas of international trade moving across the world by ship. In fact, most of the general cargo is transported in containers and the increase in volume of containerised cargo has been increasing in the last decades. On most major routes a doubling of volume occurred in less than ten years and the current fleet of container ships with a total capacity of 7 million Twenty foot Equivalent Units (TEU) has also doubled since 1997 (Europoort Magazine, 2004). Moreover, ship size is still increasing and van Ham scrutinise the future development of containerships in this perspective. From a historical perspective a trend is described towards vessels of 10.000 TEU. Already on the drawing board are Ultra-Large Container Ships (ULCS) up to 12,500 TEU such as Suez-max and even Malacca-max container carriers (18,000 TEU). However, it seems that for these mega container ships new technical and logistical concepts are needed. Via desk research the pros and cons of such vessels are identified. Executives of major container shipping lines in Asia and Europe have been interviewed in order to draw some conclusions on the feasibility of the mega carriers. The trend of increasing ship size has not yet come to an end; growing (Asian) markets require container capacity and shipping lines will provide it. Technically speaking mega carriers are feasible but from an economic point of view the benefits are small. Momentarily traditional concepts are stretched to their limits but the advent of a new generation of container ships will be based on twin screw with two engines. If this technical innovation proves a success the next frontier is the Suez-max vessel up to approx. 12,500 TEU while the ultimate container vessel, the Mallaca-max, probably has too many limitations to become a new standard.

Kreutzberger in his paper discusses the relevance that distance and time have from the shipper's point of view and analyses operator's response. Usually, in fact, freight transport evaluations suggest that (direct) transport costs are the most important aspect followed by (time) reliability and transport duration. The relevance of transport time is a matter of dispute and one can observe that customers of road transport attribute to time a relatively high priority whereas those of intermodal (rail) transport – according to numerous studies – a relatively low one. The relevance of transport time also seems to depend on its definition and that of frequency and flexibility. Under this respect the paper shows that: all cost performances deserve a thorough evaluation; intermodal rail transport time ought to be taken into serious consideration, as long as customers of road transport highly value transport time; and the design of transport services should explicitly consider indirect transport costs for the shipper in such a way that an increase in indirect costs is covered by a decrease of direct ones.

Furthermore the paper discusses the issue of the increase in transport speed, distance and time in complex bundling networks characterized by intermediate nodes for load units exchange. In this case the choice of roundtrip speed versus bundling influence distance, time, and hence vehicle costs.

Finally Macharis in her paper scrutinies the issue of the evaluation process for transport projects. The increasing complexity of transport projects' evaluation implies that different aspects have to be taken into account since the consequences of the projects are usually far reaching and the different policy alternatives are numerous and difficult to predict. Macharis points out that several pressure or action groups have also emerged causing an even more complex decision making framework to emerge. The use of multi criteria analysis for the evaluation of transport projects has increased due to the growing complexity of the problem situation and stakeholders should be incorporated explicitly in the evaluation process.

The paper, after introducing the concept of stakeholders in the existing evaluation tools for transport projects, discusses a multi stakeholder, multi-criteria analysis methodology that has been developed for decisions in the transport sector. Finally the methodology is illustrated by applying it to some case studies. The paper proposes some interesting conclusions. In fact, the evaluation of transport projects involves several stakeholders and several criteria have to be included to take care of them. The methodology proposed allows to incorporate these points of view and several criteria in the analysis. The methodology has been applied in a variety of projects, ranging from the evaluation of infrastructure projects up to the evaluation of new technologies. Including stakeholders into the analysis takes more time at the beginning, but the acceptance of the proposed solution will be higher in the end.

For this special issue we would like to thank all the people who were in Lugano: Romeo Danielis, Luca Gambardella, Bart Jourquin, Rob Konings, Ekki Kreutzberger, Sabine Limbourg, Andrea Rizzoli, Roman Rudel, Hans van Ham and Bart Wiegmans, Simona Bolis and Yvonne Bontekoning. In Lugano very fruitful comments and suggestions were given on the papers presented. Our cluster members were also willing afterwards to act as referees in order to contribute to the improvement of the papers now appearing in this special issue. Special thanks goes to Simona Bolis who was our host in Switzerland, together with Rico Maggi who lead us to a typical local restaurant and also showed us the night life in Lugano.

Cathy Macharis and Edoardo Marcucci

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Freight transport demand in the mechanics' sector of Friuli Venezia Giulia: the choice between intermodal and road transport

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Abstract

During recent years, freight transport has been experiencing an enormous growth, affecting in particular the road transport. In Italy as well as in most developed countries, this has called for appropriate policies aimed at a modal switch. A notable role in this context could be played by intermodal transport. This paper supplies a new transport attributes' evaluation, estimating the possibility that firms rely on intermodal transport rather than on road transport. Consistently, the transport mode is threaded as a choice attribute. Differently from other studies (see for example Matear and Gray, 1993 and Lu, 2000), the modelling framework introduces attribute cut-offs (Swait, 2001), in order to account for a two-stage decision process. The dataset used for this study is the result of 30 interviews, which have been realised in the Italian region of Friuli Venezia Giulia. Results show that the transport mode does not represent a discriminatory choice variable, while attributes related to the quality level of the service (e.g. damages and losses) are as important as cost attributes.

Keywords: Discrete choice models; Freight transport attributes; Cut-offs.

1. Introduction

The van Miert report dating back to the end of June 2003 represents, after the White Book, an important moment for the transportation politics in the enlarged EU, introducing a new vision of the European transportation system. It replaces the traditional individual mode approach with the concept of a seamless intermodal transportation system which is to be efficient, safe and environmentally sound. In this framework the intermodal transport has to be considered as a possible alternative to currently adopted more road-oriented solutions.

In this background, this paper aims to analyse the position of the freight transport demand with reference to the introduction of politics supporting the intermodal transport. The importance given by the mechanics' companies of the Italian region of Friuli Venezia Giulia to the attributes of the transport service is investigated, giving particular attention to the modal choice.

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The study is composed by four parts:

- sampling;
- data gathering;
- database construction;
- results' analysis.

2. Sampling

The sample considered has been constructed basing on four criteria, which correspond to the trade-off between disposable resources for this survey and theoretical principles.

The first criterion deals with the industrial system of Friuli Venezia Giulia, which is based on few very relevant sectors (furniture, mechanics, metal mechanics) and a large number of minor sectors. In this context, it has been decided to concentrate the attention on the mechanics' sector.

The second criterion takes into consideration the geographical position of the companies. The selected sample mirrors the settlement density at provincial level and for each company takes into consideration the different accessibility degree to the main regional transport infrastructures.

The third criterion (relating to the company dimension) supposes that larger companies present a more complex and therefore more developed logistics than in smaller companies. For this reasons, medium-large enterprises have been preferred to smaller ones.

The last criterion reveals to be of basic importance for the analysis of companies' position towards intermodal transport and allow selecting only those companies which are using medium-long distance (i.e. above 400-500 km) transport services. At these distances intermodal transport is an option against road transport.

3. Data gathering

The gathered data were collected during an interview and cover the socio-economic features and the preferences about freight transport for each company. Each interview has been recorded on digital support.

3.1 The Phone Pre-Interview

The phone pre-interview was made up by two questions and was used to build the sample. The first of these was aimed at excluding all those companies selling *ex works* or buying *cost insurance and freight* (CIF), which would be therefore trivial for the study. The second question was aimed at asking the interviewee to consider a concrete shipment case study, having particular importance for his/her company. This was called benchmark shipment. According to these two questions the disposability and the possibility to use the intermodal transport was investigated for each company.

3.2 The Preliminary Interview

The first part of the interview, also called preliminary interview, follows the outline represented in table 1. The benchmark shipment, which is important for the company and interesting for the survey, is considered as baseline to define the discrete choice experiment. The interviewee has been asked to define the physical-merceological as well as economic features of the benchmark shipment, making a difference between actually used transport mode (usually road transport) and the hypothetical alternative (intermodal transport). This information allows comparing the revealed with the stated preferences, which were obtained during the hypothetical choice exercises.

Table 1: The preliminary interview

2. Preliminary interview

1. The benchmark shipment

1.1. Description of the usually received/sent shipment (please make an example):

a. value:
b. weight:
c. volume:
d. merceological typology:

1.2. Description of the usual shipment along with the following aspects:

	Actual choice	Perceived alternative
Origin		
Destination		
Cost (door to door)		
Trip time (door to door)		
Delayed arrivals (%)		
Frequency of damages and losses (%)		
Average amount of damage/loss		
Shipment frequency (weekly)		
Flexibility		

1.3. degree of representatives of the benchmark transport:

2. cut-off definition:

[…]

During the second part of the interview, data on interviewee’s cut-offs were gathered. The concept of cut-off (see Swait, 2001) is explained by the following consideration: Due to their limited capabilities and resources as information processors, decision makers adopt a two-stage decision process. In the first stage alternatives are screened by a non-compensatory process and in the second one, they are evaluated via a compensatory decision rule (see Manski, 1977). The present article will not concentrate on the cut-off topic and related models, leaving this to Marcucci (the same review). Just some results will be briefly taken into consideration in the following paragraph.

3.3 The Conjoint Analysis Test

The second part of the interview contains the conjoint analysis test, aiming at gathering data on companies' preferences about transport service choice[1]. In order to put the interviewee at ease with the test, a direct qualitative valuation experiment has been introduced. It has been asked to indicate the importance degree of each attribute of the freight transport service, according a scaling of 5 levels (from 1 to 5).

The conjoint analysis test is composed by 15 choice exercises, offering the choice among three transport alternatives, two of which are hypothetical and the third one having the same features of the benchmark transport. Table 2 shows the 7 attributes describing each transport alternative together with all the related levels.

Table 2: Attributes and levels considered in the conjoint analysis test

Attributes	**Levels**
Mode:	Intermodal Road
Shipment cost:	Current Less than 5% More than 5% Less than 10% More than 10% Less than 15% More than 15%
Time:	Current Less than half day More than half day More than one day More than two days
Time reliability:	100% of shipments are on time 85% of shipments are on time 70% of shipments are on time
Damages and losses	Damages' and losses' probability equal to 0 Damages' and losses' probability equal to 5% Damages' and losses' probability equal to 10% Damages' and losses' probability equal to 20%
Frequency	High Low
Flexibility	High Low

[1] The experiment has been carried out using the ChoiceBasedConjoint (version 2.6) software, produced by Sawtooth Inc.

Basing on the specified attributes and levels, the software produces the required number of choice exercises.

3.4 The In-Depth Interview

Finally the interviewee has been asked some questions which allow a better understanding of the decisional processes of the each company. Questions regard in particular:

- dimension and company geographical structure;
- production sector and position in the supply chain;
- company logistics;
- transport service management;
- possibility and disposability for intermodal transport.

Due to the lack of space, it is not possible to represent the entire outline of the in-depth interview, which can be found in Zotti (2004).

The gathered information allow socio-economical analysis's and a global valuation of each company as well as the sample segmentation, offering the opportunity to study how different company features influence and limit the choice making process.

4. The sample obtained

The sample obtained is composed by 30 companies, the 57% of which have a turnover up to 10 millions euros, the 27% with a turnover between 10 and 25 millions of euros and the remaining 16% with a turnover above 25 millions euros per year. The features of the average benchmark transport are depicted in table 3.

Table 3: The average benchmark shipment

Transport service attributes	*Average figures*
Mode	road (100%)
Distance (km)	1.063
weight (t)	25,18
Cost (door to door) (€)	901,75
Unit price (€/tons-km)	0,40
volume (m^3)	36,29
Value of the goods shipped (€)	36.260
Time (days)	2,98
Delayed arrivals (intermodal)	60,20%
Delayed arrivals (road)	0
Damages' and losses' frequency	1,32%

5. Results

Basing on the large number of data gathered, it is possible to present different results typologies. Some of these will be discussed in this paper while other will be just mentioned. For further details see Zotti (2004).

5.1 The Preliminary Interview

Thanks to the preliminary interview, a number of data have been gathered, which allow to discuss the results reported hereby. As to the revealed preferences, the comparison with the actual transport data has given the opportunity to quantify (see table 4) how intermodal transport is perceived. In each table column, information about the attributes where intermodal transport is considered better, worse or equal to road transport is reported. As can be observed, only under the cost aspect the intermodal transport is perceived better than the correspondent road transport by the majority of the interviewed companies. On the other side, the intermodal transport is considered to be not convenient as to trip time, damages and losses and flexibility.

Table 4: Intermodal transport general perception

	intermodal > road		*intermodal < road*		*intermodal = road*		*total*
cost	16	53%	13	43%	1	3%	30
Time	7	23%	20	66%	3	10%	30
Time reliability	5	17%	6	20%	19	63%	30
Damages and losses	0	0%	18	60%	12	39%	30
Frequency	0	0%	4	13%	26	86%	30
Flexibility	2	7%	20	67%	8	26%	30

The cut-off data processing has allowed calculating the average cut-off for each attribute (table 5). For each attribute, the average cut-off is a border level indicating that every alternative containing a level equal or higher than the cut-off is rejected by the average individual. In particular the cut-off on the intermodal time reliability shows that the average individual do not accept alternatives containing a number of delayed shipments higher than 89,50%.

Table 5: Average cut-off for each attribute

Attribute	*Average cut-off*	*cut-off explanation*
Mode	6,67%	= 2 companies over 30 do not accept intermodal transport
Cost	4,98%	= highest acceptable increase (%)
Time	1	= highest acceptable increase (days)
Intermodal time reliability	89,50%	= highest acceptable delayed shipments (%)
Road time reliability	4,10%	= highest acceptable delayed shipments (%)
Damages and losses	0,38%	= highest acceptable damages' and losses probability

In particular, table 6 present the number of companies which are ready to accept a greater and greater cost increase.

Table 6: Cost cut-off

highest acceptable cost increase	*Number of entreprises*	
Up to 5%	17	57%
5% - 10%	4	13%
10% - 15%	8	27%
15% - 20%	0	0%
Up to 30%	1	3%
TOTALE	*30*	*100%*

5.2 The Multinomial logit Model

The best estimate of the multinomial logit model is presented in table 7.

Table 7: Multinomial logit model (with intermodal time reliability)

		Coefficient	*t-statistic*	*p-value*
MODE		0,24328057	0,605	0,5450
COST		-18,7747126	-9,463	0
TIME		-0,80895414	-4,421	0
INTERMODAL TIME RELIABILITY		0,56995283	1,792	0,0732
DAMAGES AND LOSSES		-56,1692305	-10,220	0
FREQUENCY		0,48439638	1,116	0,2643
FLEXIBILITY		-0,83121859	-1,913	0,0557
COSTANT		0,33897969	1,267	0,2053
Log-likelihood			-152,2240	
Adjusted r-squared		No coefficients	0,67851	
		Constants only	0,60198	

It can be noticed how the model significance is satisfactorily high and how some attributes such as transport cost, damages and losses and trip time have the correct sign and are statistically significant. Flexibility and time reliability have the correct sign but are less significant while frequency and mode are not significant. The result about this last attribute proves that most companies are indifferent to the mode used for the production of the transport service if the quality level of the service is satisfactory. This is an important result if referred to the transport politics. With reference to the time reliability attribute, some considerations will be made in the following paragraph.

The model just presented is the result of a number of estimates of different model specifications: a first model, provided with all the attributes and the two alternative specific constants, and other models, without the non-significant variables. The comparison between these models has allowed excluding the presence of any systematic distortion in the data and has suggested maintaining the full specification with all attributes. Furthermore, the model with only one alternative specific constant, (which is the one relating to the third alternative, the benchmark transport) has been estimated in order to check if there is a negative inertial factor towards the status quo. The results allow rejecting the hypothesis that such a factor exists.

The interpretation of the time reliability attribute has proved something problematic. During the carrying out of the interviews, it has been perceived that the definition of the reliability concept given a-priori (a shipment is on time if it arrives within an hour delay), which we will call intermodal time reliability is not a significant one for the enterprises belonging to the mechanics' sector. For this production sector, the concept of time reliability is less strict, being a shipment considered on time if it arrives within a half day delay (let's call this road reliability). The variable reliability has been therefore revised and a new model has been estimated, which is represented in table 8. The model with this new specification has better statistical qualities and the time reliability variable itself gains in statistical significance.

Table 8: Multinomial logit model (with road time reliability)

	Coefficient	*t-statistic*	*p-value*
MODE	0,25819034	0,635	0,5253
COST	-19,3767711	-9,386	0
TIME	-0,85474372	-4,541	0
ROAD TIME RELIABILITY	4,18124610	3,490	0,0005
DAMAGES AND LOSSES	-57,5910158	-10,301	0
FREQUENCY	0,35980021	0,813	0,4163
FLEXIBILITY	-0,91679317	-2,057	0,0397
COSTANT	-0,57562537	-1,908	0,0564
Log-likelihood		-147,3871	
Adjusted r-squared	No coefficients	0,68873	
	Constants only	0,61462	

5.3 The Mixed Logit Model

The mixed logit model (also called random parameter logit model, see Hensher and Greene 2003, Train 2002) allows representing, by defining the choice set of each individual, the choices of every agent in auto-correlated way. This is the typical tool to manage multiple choice experiments basing on stated preferences regarding more individuals. Since these observations are understandably correlated, the mixed logit model permits to represent the changes between the preferences of the different individuals.

Considering the second version of the multinomial logit model presented in the previous chapter as the starting point for our analysis, the first step lies in understanding for which variable the coefficient is to be considered random. Given the 7 independent variables, a number of estimates showed that two of them (frequency and flexibility) are not to be considered as having random coefficients since these results to be not significant. The coefficients of the other 4 main variables (cost, time, reliability, damages and losses) are all worth to be considered as random. This is represented in table 9.

Table 9: Random Parameter Logit Model (with road time reliability)

	Coefficient	t-statistic	p-value
Random parameters in utility functions			
COST	-31.0199861	-6.463	0
TIME	-1.64073846	-3.274	.0011
ROAD TIME RELIABILITY	10.6044812	2.845	.0044
DAMAGES AND LOSSES	-108.443868	-5.422	0
Non-random parameters in utility functions			
MODO	0.61639195	0.931	0.3521
FREQUENCY	-0.03130871	-0.047	0.9627
FLEXIBILITY	-2.37330714	-2.816	0.0049
COSTANTE	-1.26233102	-2.590	0.0096
Derived standard deviations of parameter distributions			
COSTO	5.93507477	0.749	0.4536
TIME	1.86996119	2.792	0.0052
ROAD TIME RELIABILITY	9.14118599	2.624	0.0087
DAMAGES AND LOSSES	42.3012980	4.151	0
Log-likelihood		-130.2454	
Adjusted r-squared	No coefficients	0.73299	
	Constants only	0.66928	

The results presented in table 9 are the last stage of a process involving a number of estimates whereby each of the four significant variables of the model was introduced one by one. In doing so, it could be shown that the random coefficient of each considered variable was actually significant and the larger the number of random coefficients the higher the quality of the model.

As to the modal variable, this is not intrinsically significant, as explained above. For this reason the introduction of this variable as a random coefficient variable means a light improvement of the quality of the model, changing the R-squared adjusted from 0.73299 to 0.73477 (no coefficients) and from 0.66928 to 0.67149 (constants only). The mode coefficient remains obviously insignificant.

5.4 The Latent Class Model

The latent class model assumes that the sample considered can be divided into a number of groups, each one having homogeneous preferences within them but different among them. In our case we will apply the structure of the latent class model assuming that the groups are justified by socio-economic differences which are represented by the corresponding socio-economic variables, which were gathered during the in-depth interview.

The results of the model cover the probability values to belong to each class. In addition the model estimates a set of coefficients for each class. There are no tests about the right number of classes. There are however some criteria which are worth to be mentioned. The Akaike criterion (AIC) and the Bayesian information criterion (BIC) are two of them. Both criteria have to be handled with care: according to McLachlan e Peel (2000) the AIC can sometimes overestimate the number of classes while the BIC underestimate it. This holds in particular when the sample is small. Taking all this into consideration, table 10 represents the results of the two just mentioned tests for the case of one class only, of two and three classes. In addition, model quality data of the above estimated random coefficients model are given as comparing term.

A look at the table shows a clear consistence of the two criteria, indicating the most appropriate number of classes equal to 2. The BIC, as underestimating criterion of the number of classes, shows that two classes exist, while a larger number of classes seems not appropriate. The same result is given also by the AIC, which despite its possible overestimation qualities confirms the result given by the BIC.

Table 10: Latent Class Model: The number of classes

n. segments	*Coefficients*	*LL*	*LL0*	*R-squared*	*AIC*	*BIC*
1	8	-158,0712	-494,3755	0,680	332,1	171,7
2	16	-119,9256	-494,3755	0,757	271,9	147,1
3	24	-116,7713	-494,3755	0,764	281,5	157,6
RPL	8	-130,2454	-494,3755	0,737	276,5	143,9
sample size	30					

Taking the model with two classes into proper consideration, table 11 shows the two coefficient sets and the together with the estimated latent class probabilities.

Table 11: Latent Class Model: The number of classes

	Class 1		
	Coefficient	t-statistic	p-value
MODE	-1.06094021	-1.084	0.2781
COST	-22.0875757	-4.108	0
TIME	-2.89520791	-5.868	0
ROAD TIME RELIABILITY	13.2361387	3.918	0.0001
DAMAGES AND LOSSES	-40.6395990	-5.325	0
FREQUENCY	1.28859892	1.098	0.2721
FLEXIBILITY	-0.82775368	-0.697	0.4858
CONSTANT	-0.87189681	-1.307	0.1913
	Class 2		
MODE	0.83779115	1.791	0.0734
COST	-23.5894587	-11.564	0
TIME	-0.43126803	-2.480	0.0131
ROAD TIME RELIABILITY	3.01902847	2.605	0.0092
DAMAGES AND LOSSES	-76.6304182	-11.242	0
FREQUENCY	0.11765649	0.247	0.8051
FLEXIBILITY	-1.63800762	-3.330	0.0009
CONSTANT	-0.59859228	-2.124	0.0336
	Estimated latent class probabilities		
Probability class 1	28,461%	3.231	0.0012
Probability class 2	71,539%	8.122	0
Log-likelihood		-135.5376	
Adjusted r-squared	No coefficients	0.72056	
	Constants only	0.65389	

As we can read from the table, the two classes are clearly defined. From one side there is a class having time constraints. This is represented by the time coefficient (-

2.89520791) and by reliability coefficient (13.2361387) which are both higher than in the other class. On the other side there is a class which is not interested in the time quality aspects of the transport service but rather in the safety aspects. A slower and even less time reliable but safer transport as to damages and losses is preferred. The two classes are however homogeneous from the cost point of view, as can be seen from the two coefficients.

6. Concluding remarks

The results obtained from this study refer to a homogeneous sample of enterprises: they all belong to the same production sector and are all located within the Friuli Venezia Giulia Region. All these features allow us to support the idea that the information obtained from this study are rather robust.

The study is composed by three parts (preliminary interview, conjoint analysis test, in-depth interview). Each one represents a different information source. The quality of the data gathered as well as of the robustness of the conclusions reached are confirmed by the consistency between the different information sources. For example the results emerging from the direct quality valuation show that the two most important attributes are the cost and the damages (on a scale from 1 to 5, the former shows a value of 4,10 and the latter of 4,5). Trip time is also important (3,63). Mode is not important at all (1,86), as indicated also by all the econometric models.

The econometric estimates confirm the good quality of the data and of the interviews generally, as indicated by the estimates of the constants' coefficients. As to the singular attributes of the transport service, the t-test is evidence for the importance given to the cost and to the damages' coefficient. Time reliability and trip time are also important. The value of the coefficients, as evidence of the degree of the importance of a variable, confirms the importance of the cost and damages. Maybe due to the definition of the frequency and flexibility these two variables have not supplied a particular high information level.

Data gathered during this survey supply a broad range of both qualitative and quantitative information which can not be reproduced here. An important field of analysis would be that of segmentation analysis, in order to understand the relationship between the socio-economic characteristics and the preference structure about the attributes of the transport service.

An important part of this research involves however models of particular nature as the random coefficients model and the latent class model. The RPL model, allowing for a more complex covariance design, permits to capture the unobserved heterogeneity which is due to socio-economic but also to more typical taste and constraint aspects. In our case the importance of the unobserved heterogeneity is illustrated by the higher level of the r-squared in the RPL model with reference to the more traditional ML model. On the other side, however, the results emerging from the estimate of the latent class model suggest that the sample can be significantly divided into two classes, which have different tastes and needs. A further task would be the numerical analysis in order to understand which company belongs to which of the two classes.

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Mode choice models with attribute cutoffs analysis: the case of freight transport in the Marche region

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Abstract

This paper shows that, when modelling freight demand, taking into consideration the presence of attribute cutoffs is important and has relevant repercussions on the estimates of service attributes coefficients. In this paper we focus on mode choice models for freight transport demand in the Marche region in Italy. Specific reference is paid to furniture and metallurgic productive sectors given their relevance for the region and their potential vocation for intermodal transport. Preference elicitation is done using choice based conjoint analysis. The study shows that there is a structural difference among the two sectors and that they have heterogeneous preferences.

Keywords: Intermodality; Freight transport; Non-compensatory choice.

1. Introduction

This paper studies mode choice in freight transport using an extension of the traditional compensatory utility maximisation framework which constitutes the base of most theoretical and statistical research in choice modelling, in general, and in transportation demand estimation, in particular.

The paper is innovative under two different aspects. Methodologically it adopts a new way of modelling choice in discrete situations. In fact, the analysis of attributes cutoffs is directly incorporated in the formulation of the decision problem. The constraint implicit in the idea of a cutoff, separating compensatory from non compensatory choices, proves sometimes to be "soft", in the sense that it is defined as a constraint *ex ante*, but is viewed as violable and compensable *ex post* (see Swait, 2001). This methodological innovation makes room for the formulation of penalised utility functions that allow for violation of "soft" cutoffs at the cost of a reduction in the utility perceived. The theoretical innovation is proven to be amply consistent with observed choices using data derived from a series of stated preference exercises.

The paper is also innovative for the research field chosen. In fact, the idea of studying mode choice for freight in territorially concentrated industrial districts in Italy

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represents an original application of the methodological tools previously described. In fact, according to recent data (Conto Nazionale dei Trasporti, 2001) a great amount of freight does not travel longer than 150 Km in Italy and predominantly originates from industrial districts. All these aspects, along with the increase in freight frequency, the reduction in volume and weight, and an ever increasing use of roads concentrated in highly populated areas, have attracted a great attention at both local and national level. In accordance with European transport policy initiatives, Italy is trying to stimulate a different mode choice for freight transport. The backbone of the modal shift policy has been so far concentrated on intermodal and train subsidisation. This unidimensional policy perspective might be not completely correct.

The present paper will show that, using non compensatory mode choice models with attribute cutoffs analysis, the actual substitutability between different attributes is quite low, at least in the sectors anlysed.

The paper is structured as follows. Section 2 describes in detail the problem studied and Section 3 the method of analysis employed. The interviews and the data collected are illustrated in Section 4. Section 5 deals with data modelling from both compensatory and non compensatory perspectives, while Section 6 proposes some concluding remarks.

2. The problem studied

The present paper is *de facto* the natural continuation of a previous research conducted on freight transport, logistic and modal choice, studying the economic pre-requisites for modal shift in Italy. The research programme had been financed by the Italian Ministry of University and Research and has produced, as a final result, a book edited by Borruso and Polidori (2003). Following the research suggestions formulated in the concluding remarks of that book, the present paper focuses on only two specific productive sectors, DJ (metallurgy) and DN (furniture), and uses non compensatory mode choice models with attribute cutoffs analysis to solve the impasse that was encountered in the previous research when acknowledging both the limitations linked to the use of unacceptable levels, as well as those due to the adoption of partial profile designs of the questionnaire (Polidori and Marcucci, 2003). The choice of concentrating on only two productive sectors is due to the attempt of separating *ex ante* the maximum possible sources of heterogeneity. In fact, as it has often been recalled (Danielis, 2002), freight transport, especially when compared with passenger transport, is profoundly characterised by a strong heterogeneity in the preferences. Reducing the field of analysis to only two productive sectors and modelling their preferences separately, the number of sources of heterogeneity is restricted since it is more reasonable to assume that, within the same productive sector, the companies are more similar in terms of organisation, specific needs of the particular logistic chain the company belongs to, structural characteristics of freight transport, etc.

The choice of the productive sectors is linked, on the one hand, to the number and concentration of companies in the Marche region (furniture in the Province of Pesaro-Urbino and light mechanics in the Province of Ancona) and, on the other, to their potential vocation towards intermodal transportation. The shoe sector (strongly represented in the Province of Macerata), for example, was not studied since it has an inherent low inclination to intermodal transport, due to the its structural (industrial, commercial, distributive, etc.) characteristics.

The paper deals with the issue of estimating the relative weight of the various attributes characterising freight transport services such as: cost, trip length, punctuality, risk of damage and loss, flexibility and frequency. The aim is to estimate their importance in determining the modal choice of the companies acquiring the service on the market. The issue is analysed taking into consideration that there might well be a specific attribute (or more), within the service profiles among which the interviewed has to choose, that would not be willingly considered acceptable. Given the great modal unbalance in freight transport in favour of road the study wants to analyse and discover which are the attributes that have the greatest influence on the final choice. Under this respect, cutoff analysis is specifically directed to understand if there is an area of substitutability among the different attributes and, if so, estimate how large it is. The ultimate aim is to verify if the policies put forward by the government, mainly aimed at service subsidisation, will have an effect and how large it might be. The often cited "service quality" is deeply scrutinised. In other words, the paper tackles the modal shift problem through the study of the specific characteristics of the preferences of the companies actually buying the service. The theoretical underpinning of the study is the rational consumer ability to judge correctly the welfare effect of his own actions. If the assumption holds one has consequently to investigate which are the characteristics that make road freight transportation preferred. Turning the reasoning around, one has to question which are the characteristics of intermodal transportation perceived as non satisfactory and leaving space for intervention.

3. The research method

The method used to conduct the research is Choice Based Conjoint (CBC). For all the details concerning the method and the characteristics of the software used, the reader should refer to www.sowtoothsoftware.com.

We used a *full profile* design with a pre-interview during which all the unacceptable attribute levels had to be stated. This information is extremely important since it will be used in the subsequent estimation process. In fact the choice exercises proposed will include also the levels declared as unacceptable *ex ante*. Each choice experiment foresees the possibility of opting for a service that has exactly the same characteristics as the one the company is *de facto* using (revealed preferences). An example of an actual choice experiment is reported in Table 1.

Table 1: Example of choice profile used.

Choice profile A	***Choice profile B***	***Choice profile C***
Intermodal mode	Road mode	Present transport mode
10% cost increase	10% cost decrease	Cost equal to the current one
0.5 days increase in duration	0.5 days decrease in duration	Duration equal to the current one
85% on time delivery	70% on time delivery	% of on time deliveries equal to the current one
10% probability of damages	15% probability of damages	Probability of damages equal to the current one
Low service frequency	High service frequency	Service frequency as at present
Low service flexibility	High service flexibility	Service flexibility as at present

The range of attribute levels employed is reported in Table 2.

Table 2: Levels of the attributes considered.

	Cost	Travel time	Punctuality	Damages	Frequency	Flexibility	Mode
Level 1	-15%	+2 days	100%	0%	High	High	Road only
Level 2	-10%	+1 day	85%	5%	Low	Low	Intermodal
Level 3	-5%	+1/2 day	70%	10%			
Level 4	Present level	Present level		20%			
Level 5	+5%	-1/2 day					
Level 6	+10%						
Level 7	+15%						

4. Interviews, database and results

The sample was drawn from the list of companies provided by ISTAT and updated in occasion of the 2001 census. The focus was on companies with forty or more employees based on the hypothesis that for these companies it was more likely to clearly locate a person in charge for logistics to be interviewed. The number of employees being a proxy of the companies' dimension and relevance, the choice made also allowed to restrict the study to those companies with a larger number of shipments and arrivals. Restricting the reference population also allows for a higher fraction of it to be sampled. Table 3 reports the total number of companies in the two productive sectors investigated for each province of the Marche region.

Table 3: Provincial distribution of companies in the DN and DJ sectors.

Province	DJ	DJ %	DN	DN %
AN	154	36.7%	69	19.9%
PU	115	27.4%	196	56.6%
MC	80	19.0%	65	18.8%
AP	71	16.9%	16	4.6%
Total	420	100%	346	100%

Table 4 reports the number of companies to be included in the sample for each sector and each Province.

Table 4: Provincial distribution of companies in the DN and DJ sectors in the sample design.

Province	DJ	DJ %	DN	DN %
AN	19	40.4%	19	24.4%
PU	14	29.8%	48	61.5%
MC	4	8.5%	7	9.0%
AP	10	21.3%	4	5.1%
Total	47	100%	78	100%

The ratio of companies effectively interviewed for sector DJ is reported, with a province detail, in Table 5.

Table 5: Provincial comparison between companies to be included and companies effectively included in the sample for the DJ sector.

Ancona

Ateco	*To be included*	*Effectively included*	*%*
28.11.00	3	4*	100
28.52.00	6	2	33.33
28.75.00	10	6	60
Total	19	12	63.16

Pesaro

Ateco	*To be included*	*Effectively included*	*%*
28.11.00	8	5	62.5
28.52.00	4	3	75
28.75.00	2	0	0
Total	14	8	57.14

Macerata

Ateco	*To be included*	*Effectively included*	*%*
28.11.00	1	0	0
28.52.00	1	0	0
28.75.00	2	1	50
Total	4	1	25

Ascoli – Piceno

Ateco	*To be included*	*Effectively included*	*%*
28.11.00	5	3	60
28.52.00	2	0	0
28.75.00	3	1	33.33
Total	10	4	40

Note: in the case signalled by the symbol * there was an excess of companies interviewed since not all those that were first contacted promptly responded and, while waiting for a reply, they were cautiously not included in the sample and new companies were, in the meanwhile, contacted that were willing to participate to the experiment. Subsequently part of the companies that had not replied decided to participate thus creating the excess.

The ratio of companies effectively interviewed for sector DN is reported, with a province detail, in Table 6.

Table 6: Provincial comparison between companies to be included and companies effectively included in the sample for the DN sector.

Ancona

Ateco	*To be included*	*Effectively included*	*%*
36.11.00	2	2	100
36.12.00	6	3	50
36.13.00	5	1	20
36.14.00	6	3	50
Total	19	9	47.37

Pesaro

Ateco	*To be included*	*Effectively included*	*%*
36.11.00	3	2	66.67
36.12.00	10	4	40
36.13.00	7	3	42.86
36.14.00	28	9	32.14
Total	48	18	37.50

Macerata

Ateco	*To be included*	*Effectively included*	*%*
36.11.00	1	0	0
36.12.00	1	0	0
36.13.00	2	1	50
36.14.00	3	1	33.33
Total	7	2	28.57

Ascoli – Piceno

Ateco	*To be included*	*Effectively included*	*%*
36.11.00	1	0	0
36.12.00	0	0	-
36.13.00	0	0	-
36.14.00	3	1	33.33
Total	4	1	25

A database of 2295 observations was collected by administering 15 choice exercises to each of the 51 companies interviewed.

The choice experiments may or may not include levels of the attributes violating the cutoffs. Table 7 reports the total number of violation for each attribute in the interviews administered.

Table 7: Cutoffs presence in the choice profiles.

	Cost	**Duration**	**Punctuality**	**Damages**
Absolute frequency	390	559	618	1027
Percentage	16.99%	24.36%	26.93%	44.75%

Table 8 illustrates how often an alternative characterised by some cutoff violations has been nevertheless chosen.

Table 8: Number of alternatives chosen characterized by cutoff violations.

	VK Mode	**VK Coso**	**VK Duration**	**VK Punctuality**	**VK Damages**
Total	59	15	328	433	618
Mean	2.57%	0.65%	14.29%	18.87%	26.93%

Table 9 gives account of the model employed for the estimation of the preferences of the two sectors jointly. The model used is a simple multinomial logit model and was estimated using NLOGIT 3.0 that is part of LIMDEP 8.0 (www.limdep.com). The first model estimated includes, as explicative variables, all the attributes considered. Two dummy variables (assuming the value 1 when the alternative chosen is, respectively, the first or the second one and 0 otherwise) were also included in order to verify the existence of any distortion due to answer position within the choice profile.

Table 9: LM – All attributes plus dummy one.

Variable	**Coefficient**	**Standard error**	**b/St.Er.**	**p-value**
MODE	0.7206	0.2041	3.530	0.0004
CPER	-9.7986	0.9022	-10.860	0.0000
DVA	-0.2721	0.0934	-2.914	0.0036
PUCH	2.0960	0.5586	3.754	0.0002
DANNI	-14.0920	1.3782	-10.224	0.0000
FREQ	-0.2024	0.2148	-0.942	0.3460
FLESS	-0.3103	0.2152	-1.442	0.1493
A_A	-0.8495	0.1698	-5.002	0.0000
A_B	-0.8863	0.1753	-5.054	0.0000
Log likelihood function			-495.2737	
R^2 Adg no coefficients			0.4072	
R^2 Adg constant only			0.2460	

Note: MODE = transport mode; CPER = transport cost percentage variation; DVA = transport duration absolute values; PUCH = delivery punctuality; DANNI = damages; FREQ = service frequency; FLESS = service flexibility; A_A e A_B = dummies.

The coefficients are all significant, with the only exceptions of frequency and flexibility, and the relevant explanatory role of cost and damages should be noticed. Concerning the position of the alternatives in the choice profile, it can be seen that the coefficients A_A and A_B are both significantly different from zero but not statistically different from each other. This means that, after accounting for all the other factors, companies tend to choose the third alternative more often than the other two, while alternatives one and two are chosen equally often and no position distortion can be observed for them. The third alternative is, instead, the only "labeled" one, corresponding to the profile with levels of attributes equal to those of the transportation mode currently used. After accounting for all the other factors, companies seem to choose more often the alternative that they actually use. Therefore an alternative specific constant, corresponding to the *status quo* alternative, was included in the model. Results are reported in Table 10. The estimates of the coefficients clearly resemble those of the previous model.

Table 10: LM – All attributes plus ASC_SQ dummy.

Variable	Coefficient	Standard error	b/St.Er.	p-value
ASC_SQ	0.8665	0.1553	5.578	0.0000
MODO	0.7176	0.2037	3.522	0.0004
CPER	-9.7828	0.8995	-10.876	0.0000
DVA	-0.2710	0.0932	-2.906	0.0037
PUCH	2.0873	0.5571	3.747	0.0002
DANNI	-14.1059	1.3771	-10.243	0.0000
FREQ	-0.2027	0.2148	-0.944	0.3453
FLESS	-0.3103	0.2152	-1.442	0.1494

Log likelihood function	-495.3038
R^2 Adg no coefficients	0.4075
R^2 Adg constant only	0.2465

Note: MODE = transport mode; CPER = transport cost percentage variation; DVA = transport duration absolute values; PUCH = delivery punctuality; DANNI = damages; FREQ = service frequency; FLESS = service flexibility; ASC_SQ = actual transport mode dummy .

The effect of the cutoff presence was tested next. The results are reported in Table 11.

Table 11 clearly shows the strong and significant effect of cutoffs presence. In fact all the cutoffs coefficients are significant and with a negative sign as expected. Their effect on attribute's coefficients is evident. The coefficients for transport duration and punctuality are no longer significantly different from zero, meaning that, provided the cutoffs on the duration and puntuality are not violated, these two attributes do not have a relevant role in the mode choice. The coefficient of the mode variable increases demonstrating a greater propensity for intermodality, provided the company does not *a priori* refuse it. At the same time cost and damages coefficients decrease substantially given that a relevant part of their effect is now explained through the cutoffs. It is also worthwhile noticing that the coefficient of the *status quo* variable is no longer significantly different from zero. This means that companies seemed to choose the third alternative more often than the other two only because, obviously, this alternative never includes inacceptable levels of the attributes. Once cutoffs are accounted for, the preference for the *status quo* alternative disappears.

Table 11: All attributes, ASC_SQ and cutoffs dummies.

Variable	Coefficient	Standard error	b/St.Er.	p-value
ASC_SQ	-0.1131	0.2095	-0.540	0.5890
MODO	1.0266	0.2354	4.360	0.0000
CPER	-5.7868	1.2704	-4.555	0.0000
DVA	0.0931	0.1284	0.725	0.4683
PUCH	0.5130	0.8986	0.571	0.5681
DANNI	-9.0388	1.9261	-4.693	0.0000
FREQ	-0.2060	0.2233	-0.923	0.3562
FLESS	-0.2970	0.2234	-1.330	0.1837
KMODO	-0.4439	0.2285	-1.942	0.0521
KC	-1.6873	0.3599	-4.688	0.0000
KD	-0.9842	0.2375	-4.144	0.0000
KPUNTU1	-0.6539	0.2560	-2.554	0.0107
KDANNI	-0.8711	0.2484	-3.506	0.0005
Log likelihood function	-462.7620			
R^2 Adg no coefficients	0.4446			
R^2 Adg constant only	0.2937			

Note: MODE = transport mode; CPER = transport cost percentage variation; DVA = transport duration absolute values; PUCH = delivery punctuality; DANNI = damages; FREQ = service frequency; FLESS = service flexibility; ASC_SQ = actual transport mode dummy; KMODO = mode cutoff dummy; KC = cost cutoff dummy; KD = duration cutoff dummy; KPUNTU1 = punctuality cutoff dummy; KDANNI = damages cutoff dummy.

Log-likelihood substantially increases going from -495.30 to –462.76. The log-likelihood ratio statistic is equal to 65.08, with 5 degrees of freedom and amply confirms that the cutoff coefficients are significantly different from zero and, thus, the last model has better explicative capabilities than the previous one.

Hereafter, the analysis will be carried out allowing for companies in different sectors to have different coefficients for the various attributes. The coefficients for the metallurgic and the furniture sector were estimated on the basis of, respectively, 23 and 28 companies in the sample. The model has been first estimated without taking into account the presence of cutoffs in the alternatives. The results are then compared with those obtained introducing the cutoffs.

Table 12 shows the sector analysis without cutoffs. As a starting point all the coefficients were allowed to be different in the two sectors. The dimension of the model was then reduced using a stepwise procedure: at each step, all possible reduced models (obtained by constraining, in turn, each coefficient to be the same in the two sectors) are estimated and the one with the highest likelihood is compared to the current model through the likelihood ratio test. If the test turns out to be significant, the current model is considered to be the one which best explains the structure of preferences and the procedure is stopped. Otherwise, if the test turns out to be non significant, the reduced model becomes the new current model and another step is performed. The final model obtained in this way is shown in Table 12.

Table 12: Sector analysis – All attributes and ASC_SQ dummy.

	Metallurgic sector				Furniture sector			
Variable	*Coefficient*	*Standard error*	*b/St.Er.*	*p-value*	*Coefficient*	*Standard error*	*b/St.Er.*	*p-value*
ASC_SQ	0.8235	0.1562	5.271	0.0000	0.8235	0.1562	5.271	0.0000
MODO	0.7182	0.2059	3.488	0.0005	0.7182	0.2059	3.488	0.0005
CPER	-9.8525	0.9039	-10.900	0.0000	-9.8525	0.9039	-10.900	0.0000
DVA	-0.2872	0.0944	-3.043	0.0023	-0.2872	0.0944	-3.043	0.0023
PUCH	**1.0381**	**0.7081**	**1.466**	**0.1426**	**3.2705**	**0.8027**	**4.074**	**0.0000**
DANNI	-14.5319	1.4106	-10.302	0.0000	-14.5319	1.4106	-10.302	0.0000
FREQ	**0.1413**	**0.2630**	**0.537**	**0.5911**	**-0.5829**	**0.2835**	**-2.056**	**0.0398**
FLESS	-0.3003	0.2172	-1.383	0.1668	-0.3003	0.2172	-1.383	0.1668

Log likelihood function	-488.8408
R^2 Adg no coefficients	0.41452
R^2 Adg constant only	0.25537

Note: MODE = transport mode; CPER = transport cost percentage variation; DVA = transport duration absolute values; PUCH = delivery punctuality; DANNI = damages; FREQ = service frequency; FLESS = service flexibility; ASC_SQ = actual transport mode dummy . Coefficients which are different for the two sectors are in bold.

The analysis of Table 12 seems to show that the furniture sector is sensitive to delivery punctuality and service frequency, while the metallurgic sector is not. None of the sector is sensitive to service flexibility.

Table 13 reports the results of cutoffs inclusion in the model separately for the two sectors.

Including the cutoffs in the model makes again a substantial difference. In Table 13 some features, which were completely hidden in the previous model, can now be noticed. First of all, the fact that the two sectors show a quite different sensitivity to costs and damages, with the furniture sector being much more sensitive to these two attributes. This is the main difference between the two sectors and it is completely missed by the model in Table 12, where only the fact that the furniture sector is more sensitive to delivery punctuality and service frequency than the metallurgic one is captured. Notice that the importance of these attributes in differencing the sectors is much reduced in Table 13.

Table 13: Sector analysis – All attributes and ASC_SQ and *cutoff* dummies.

	Metallurgic sector				Furniture sector			
Variable	*Coefficient*	*Standard error*	*b/St.Er.*	*p-value*	*Coefficient*	*Standard error*	*b/St.Er.*	*p-value*
ASC_SQ	-0.0297	0.2143	-0.139	0.8898	-0.0297	0.2143	-0.139	0.8898
MODO	0.9983	0.2409	4.144	0.0000	0.9983	0,2409	4,144	0,0000
CPER	**-4.1001**	**1.5987**	**-2.565**	**0.0103**	**-8.7051**	**1.8152**	**-4.796**	**0,0000**
DVA	0.0809	0,1318	0,614	0,5394	0,0809	0,1318	0,614	0,5394
PUCH	**-0.0490**	**1.0298**	**-0.048**	**0.9620**	**2.2223**	**1.1870**	**1.872**	**0.0612**
DANNI	**-5.1732**	**2.9616**	**-1.747**	**0.0807**	**-13.5652**	**2.8206**	**-4,809**	**0,0000**
FREQ	**0.2065**	**0.3013**	**0.685**	**0.4932**	**-0.6812**	**0.3106**	**-2.193**	**0.0283**
FLESS	-0.3034	0.2297	-1.321	0.1864	-0.3034	0.2297	-1.321	0.1864
KMODO	**0.0559**	**0.3093**	**0.181**	**0.8566**	**-0.9815**	**0.3292**	**-2.981**	**0.0029**
KC	**-2.8979**	**0.6649**	**-4.358**	**0.0000**	**-0.7971**	**0.4338**	**-1.837**	**0.0662**
KD	-1.0304	0.2452	-4.203	0.0000	-1.0304	0.2452	-4.203	0.0000
KPUNTU 1	-0.5100	0.2699	-1.890	0.0588	-0.5100	0.2699	-1.890	0.0588
KDANNI	**-1.5964**	**0.3929**	**-4.063**	**0.0001**	**-0.2412**	**0.3353**	**-0.719**	**0.4719**
Log likelihood function	-445.7619							
R2 Adg no coefficients	0.46258							
R2 Adg constant only	0.31649							

Note: MODE = transport mode; CPER = transport cost percentage variation; DVA = transport duration absolute values; PUCH = delivery punctuality; DANNI = damages; FREQ = service frequency; FLESS = service flexibility; ASC_SQ = actual transport mode dummy; KMODO = mode cutoff dummy; KC = cost cutoff dummy; KD = duration cutoff dummy; KPUNTU1 = punctuality cutoff dummy; KDANNI = damages cutoff dummy. Coefficients which are different for the two sectors are in bold.

Looking at the cutoffs coefficients it can also be seen that the metallurgic sector has a softer cutoff on the mode of travel compared to the furniture sector. On the other hand, the furniture sector has less rigid cutoffs on costs and damages. In spite of the relevance of these two attributes in the decisional process of the furniture sector, it seems that the cutoffs of the companies on costs and damages can be compensated for through adequate levels of the other attributes. Finally, both of the sectors show a demand with low compensability for the attributes duration and punctuality. This lack of substitutability implies that a modal alternative must satisfy the companies' cutoffs on duration and punctuality to have better chances to be taken into consideration.

Finally, notice that the likelihood ratio statistic between model in Table 12 and model in Table 13 is equal to 86.158, with 8 degrees of freedom, leading to the rejection of the null hypothesis that the cutoff coefficients are all zero and, thus, confirming the better fit to the data of the last model.

To conclude this section, with regard to the model presented in Table 13, we calculate some substitution indexes which can help in interpreting the estimates obtained. The substitution index for a generic "non-monetary" attribute X is calculated as

$$SI_{XC} = -\frac{\Delta UX}{\Delta UC}$$

where ΔUX is the variation in the utility determined by a unitary variation of the attribute X and ΔUC is the variation in the utility determined by a unitary variation of the transport cost. Thus, the substitution index indicates how many times a unitary reduction in the cost of transport should be applied to compensate for a unitary variation (perceived as negative) in the attribute X. Notice that if the utility function is linear, SI_{XC} is simply calculated as minus the ratio between the estimated coefficient of the attribute X and the estimated coefficient of the transport cost.

The following substitution indexes have been calculated:

- SI_{TC} which indicates how many times a unitary transport cost discount should be applied in order to compensate a unitary increase in travel time;
- SI_{PC} which indicates how many times a unitary transport cost discount should be applied in order to compensate a unitary increase in the risk of late arrivals;
- SI_{DC} which indicates how many times a unitary transport cost discount should be applied in order to compensate a unitary increase in damage and loss risk.

Results are given in Table 14. Notice that the substitution indexes are equal to zero for those attributes with non significant coefficients. The values of travel time and risk of late arrival in euros per hour have been obtained by multiplying the respective substitution indexes for the average cost of transport separately estimated for the two sectors, and then dividing by 12 (considering a travel day made of 12 hours). The value of a 5% risk of damage and loss in euros per thousand euros of transported goods has been instead calculated by multiplying the respective substitution index for the average cost of transport separately estimated for the two sectors, dividing for the average value of transport separately estimated for the two sectors, and then multiplying by thousand and by 5%. Since transports in the two sectors are not homogeneous with regard to travel costs and value of the transported goods, the monetary values reflect, beside other factors, those heterogeneities too.

Tab. 14: Substitution indexes for the two sectors.

	Metallurgic sector		*Furniture sector*	
	Substitution index	Monetary value in Euros	Substitution index	Monetary value in Euros
SI_{TC}	0.00	0.0[a]	0.00	0.0[a]
SI_{PC}	0.00	0.0[b]	0.26	26.6[b]
SI_{DC}	1.26	1.6[c]	1.56	3.3[c]

a = value of travel time in Euros per hour
b = value of risk of late arrival in Euros per hour
c = value of a 5% risk of damage and loss in Euros per thousand Euros of transported goods

5. Concluding remarks

In this paper compensatory and non compensatory mode choice models with attribute cutoffs analysis have been studied and applied to the case of freight transport in the Marche region with specific reference to furniture and metallurgic productive sectors. Preference elicitation was done using choice based conjoint analysis. The presence and effect of cutoffs violations have been expressly considered and modelled. The overall strong significance of cutoffs parameters demonstrates that not including them in model estimation potentially provokes substantial mistakes.

With specific reference to the sector analysis proposed it is important to underline that there is a substantial difference between the furniture and metallurgic sector consisting of a lower attention, paid by the metallurgic sector compared to the furniture one, to the attributes composing service quality. A further characteristic differentiating these two sectors has to do with the different attitude towards cutoff compensability. Whereas in the furniture sector freight transport demand is more flexible and compensation is sometimes possible even in the presence of ex ante cutoffs (soft ones) the same is not true for the metallurgic sector.

The conclusions drawn from this study suggest that a rethinking of the actual Italian freight transport policy, substantially based on train, ship and intermodality subsidisation, is in order.

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An Analysis of Maritime Ro-Ro Freight Transport Service Attributes through Adaptive Stated Preference: an Application to a Sample of Freight Forwarders

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Abstract

In this paper we present preliminary evidence from a pilot study carried out with the primary objective of testing the validity of adaptive conjoint data collecting methods in analysing operators' preferences when redirecting current on-land transport services to a hypothetical maritime ro-ro service alternative. The analysis has focussed on a sample of freight forwarders. Through a combination of Revealed Preferences and Adaptive Stated Preference Experiments we have constructed a database of their preferences' toward the maritime ro-ro alternative using a set of transport service attributes: price, reliability, frequency, transit time, etc. We have estimated the relevant parameters through a Tobit model and have been able to calculate relative trade-off values among the significant attributes. The resulting ranking highlights the relative importance of reliability and frequency in the decision to switch to maritime services.

Keywords: Adaptive Stated Preferences; Conjoint analysis; Ro-ro maritime service; Freight transport; Freight forwarders.

1. Introduction

The growing interest towards a re-balancing of freight traffic over the different modes has, only recently, been accompanied by significant efforts to empirically identify the factors which might exert a significant influence on the choice of operators. Although the first large scale studies date back to the early nineties, only more recently, in fact, a sistematisation of the various experiments is taking place. It is now starting to form a relatively large sample of studies and of estimated values on the determinants of the

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operators' demand. Most of these studies focus on producers' preferences for transport services attributes. An increasing part of these studies recur to stated preference methodologies and, through differing estimating techniques, obtain an indicative valuation of the service characteristics identified as relevant for the interviewed sample (see, for instance, Regan and Garrido, 2001 and Danielis, 2002).

Our study differs from many of the previous papers on three accounts.

First, we have opted for an interactive approach which allows operators' preferences to be elicited on hypothetical alternatives. In particular, we carried out an adaptive stated preference experiment to collect an appropriate database and, given the characteristics of the data, estimated the relevant parameters through a Tobit model. The analysis has been carried out through two quantitative and qualitative surveys: a revealed preference study to obtain data on the characteristics of the "typical" transport performed by the company (functional to the stated preference experiment) and a stated preference interactive interview with a specific set of operator to learn about user preference for an hypothetical alternative service defined by a set of attributes: price, reliability, frequency, transit time, etc.

Second, most of the previous studies do not focus on a specific mode but, instead, leave the choice of the type transport mode to the respondent identifying only its attributes (Danielis, 2002). In our study, instead, we have restricted the modal choice to a maritime ro-ro service. Our decision has been dictated by the desire to analyse operatos' preferences in relation to this specific mode of transport given the growing interest of policy makers towards the spin off of initiatives directed at stimulating a re-orientation of traffic flows towards the maritime mode, and, in particular, towards ro-ro services. This approach has enabled us to analyse transport service consumers' preferences for the maritime alternative and to identify the service attributes which most influence users' attitudes towards short-sea shipping ro-ro services.

Finally, we have chosen to focus our application on freight-forwarders instead of producers. The latter has allowed us to gain insight on a part of the market for transport service, which accounts, on average, for more than half of the transport decisions. Outsourcing of transport operations is, in fact, spreading rapidly and, as a recent study by Unescap (2002) points out, freight forwarders are increasingly assuming full responsibility over the complete cycle of the transfer of the freight from door-to-door. Selecting freight-forwarding agents allows, thus, to complete the picture of the preferences of consumers' of transport services: insights can be gained from a wider spectrum of possible uses. A comparison of the outcome of our study with those of the studies focussing merely on the producers' behaviour can help us to understand whether the preferences of these two set of transport service consumers tend to converge or to diverge and, thus, whether a need exists for taking differentiated policy initiatives.

The rest of this paper is organized as follows. In Section 2 we describe the methodology used to assemble the dataset, the criteria followed in identifying the sample and the design of both the revealed preference survey and the adaptive stated preference experiment. Section 3 contains a detailed description of the database and an illustration of the estimation procedure and main outcomes. It also contains a brief comparison of the main results of other EU studies. Section 4 briefly summarizes the main conclusions.

2. Data Base Construction Methodology

2.1 The choice of Adaptive Stated Preference

In the last few years, significant improvements have been made in the definition of a methodology capable of realistically interpreting the decision-making process of operators with respect to transport service choice. The superiority of stated preference techniques versus revealed preference techniques in these instances is generally accepted, mainly due to the characteristics of the data needed for the experiments. Application of revealed preference methods based on observed behaviour is, generally, not feasible in the context of freight transport since:

- the data on actual choices is usually commercially very sensitive and hence is not usually disclosed[1];
- the complexity of the freight transport decision requires the collection of large dataset on a number of variables and the observation of a great number of firms' decisions in order to take into account the heterogeneity of the context.

Revealed preference datasets, in fact, are based on the observation of actual choices; need a large number of observations; may include only existing alternatives; and require the choice set to be defined and the level of service information for the discarded option to be calculated. Moreover, important characterising variables (such as, for instance, time and cost) are often correlated and, due to possible measurement error, there might be bias in forecasting. Finally, for the specific scope of the study, the limited use of the maritime alternative, especially for certain routes and products, is an additional reason against the use of revealed preferences in this context. The existence of an alternative which is not sufficiently used is, in fact, analogous to analysing the choice of a new alternative (Tweddle et al. 1996).

Stated preference data, on the other hand, overcome these problems, although questionnaire design and choice of the relevant attributes[2] plays a major role in their efficacy. It has the advantage, with respect to standard revealed preference approaches, of allowing analysis in contexts in which it is not possible to "observe" the real behaviour of operators either for lack of data or because the alternative to be analysed is not yet used or available for use.

More recently, a growing body of literature has been emphasising the advantages of combining revealed preference and stated preference data in order to exploit the strengths of both[3]. In the present application, however, given the need to consider hypothetical services as well, this possibility is partially precluded and – although revealed preference techniques are used in gathering data on the current choices of the pilot sample and to select a "typical" transport for each company (the current choice) – the data are mainly collected through stated preference techniques.

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[1] In a liberalised environment, freight rates are individually negotiated and held commercially confidential.

[2] On the importance of the correct specification of the influential attributes in SP analysis, the reader is referred to the detailed work of Cullinane and Toy (2000).

[3] For greater details the reader is referred to: Ben Akiva and Morikawa (1990), Adamowicz et al. (1994 and 1997), Swait et al. (1994), Bradley and Daly (1997), Stopher (1998), Wardman (1998), Brownston et al. (1999), Louviere et al. (2000).

The methodology used falls within the broad family of conjoint analysis experiments, as we attempt to determine the value that individuals place on any product as equivalent to the sum of the utility they derive from all the attributes making up a specific transport service. The conjoint alternative scenario approach is a research technique used to measure the trade-offs people make in choosing between products and service providers. It was first developed in the marketing sector and has been largely used to predict consumers' choices for future products and services, and now it is a well-established procedure in transport studies[4].

In particular, given the need to avoid offering the respondent options which are irrelevant for the respondent, we discard traditional stated preference techniques in favour of the adaptive stated preference (ASP). This interactive data collection technique amends attribute levels offered to the respondent during the experiment on the bases of the responses he gives. One significant advantage of this method in studying freight is that it makes it possible to cope with a wide range of "situations" which are comparable with the real world known by the respondent and that the experiment is trying to recover (type of commodity, time variance of attribute valuation, etc.).

The ASP experiment starts from an existing freight transport option chosen by the interviewed person. Usually this option is defined using revealed preference data and is elaborated in accordance with the person responsible for the mode choice: it is the "typical" transport of the firm (Fowkes and Tweedle 1996). Starting from this option, the ASP exercise implies asking the respondent to rate various hypothetical alternatives for performing the same transport task expressed in terms of the relevant attributes.

To our knowledge, this is the first ASP experiment performed with the scope of determining the preferences of operators in terms of service attributes of sea transport and of studying the potential reallocation of traffic from surface transport services to maritime ro-ro services[5].

2.2 Identification of the Sample: Who and Where

Differently from many previous studies, which investigate producers or suppliers[6], the present analysis has been carried out on a sample of freight-forwarders. The specific choice is based on the following reasons:

- first, it is increasingly common, especially for medium-long distance transfers, to delegate the decision on the mode to be used outside the firm to third parties: choosing freight-forwarding agencies makes it possible to intercept information from

[4] In particular, in the context of freight transport, since the late seventies – with the pioneering work by Fowkes and Tweddle (1979) – stated preference techniques have been used, among others, by Bates (1988), Ortuzar and Palma (1988), Fowkes and Tweddle (1996, 1997), Fridstrom and Madslien (1994, 2002), Bolis and Maggi (1999, 2002, 2003), Bergkvist (2001), Fowkes and Shinghal (2002), Danielis and Rotaris (2002), and Maier and Bergman (2001, 2002). For a more detailed review of literature on stated preference experiments in the freight transport sector see also Regan and Garrido (2001).

[5] A previous study carried out on the routes between Sicily and the Continent by Gattuso and Pastorino (1996) adopted standard SP methodology.

[6] Among others: Bolis and (1999, 2002, 2003), Meier and Bergman (2001, 2002) and Danielis and Rotaris (2002).

a sector of the industry which accounts, on average, for more than half of the transport decisions, as outsourcing of transport operations is spreading rapidly[7].

- Secondly, the focus on freight forwarders results in a sample which, although small, is homogeneous with regard to respondents' activity. Given the limited resources available, and in the light of extending the experiment, selecting producers would have limited the scope of the analysis to a specific productive sector or would have excessively constrained the dimension of the dataset for each industrial sector. On the other hand, choosing transporters, given the current situation of the Italian surface transport industry, would have probably led to interpretation problems due to the resistance of small operators to intermodal transport[8].
- Finally, recent studies have demonstrated that freight forwarders are becoming "one-stop shop" specialist companies (KNP 2002). According to the results of the market review carried out by Unescap in 2002, this is part of a process that has led to the blurring of boundaries between what were formerly distinct activities. There is a growing body of evidence showing that "freight forwarders, from the perspective of the shipper, assume the role of the carrier; from the point of view of the actual carrier; they assumes the role of the shipper" (Unescap 2002, p. 1).

All in all, selecting freight-forwarding agents instead of producers on the one hand allows insights to be gained from a wider spectrum of possible uses, and on the other hand, to gather a set of information on the subject who is really behind the decision-making process in transport attribute choices. Although the objective function of the freight forwarder would necessarily differ from that of the producer, it could reasonably be argued that, given the recent evolution of the market and of the contractual agreements in force, once the organisation of the transport service has been outsourced the real (final) decision maker, the shipper, would be the freight forwarder herself/himself. S/he would be the residual claimant to any cost-quality advantages obtained.

Also, in line with the scope of our investigation, we have restricted the interviewed sample to those freight forwarders who have a certain familiarity with the maritime mode and, given the purposes of this study, we have focussed the empirical application on a specific geographical context. In particular, we have analysed the preferences of freight forwarder localised in the north-west regions of Italy with respect to the possibility of accessing maritime ro-ro services from the port of Genoa. In order to present the participating freight forwarder with comparable alternatives, we have considered traffic-flows between origin-destination areas which are reachable from the area of the study both by sea and by land.

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[7] Recent surveys on the evolution of the freight forwarders business and type of services offered are contained in KNP (2002) and Unescap (2002). At the European level interesting insights are given by Logiq (1999).

[8] Recent studies highlight (Tsamboulas and Kapros 2002) the widely differing expectations different groups of users have for transport service attributes, especially in relation to multimodal transport services, and they indicate that intermediaries have, in general, a more in-depth knowledge of possible alternatives. Moreover, when producers externalise the logistic and/or transport function they tend to be less concerned with the actual characteristics of the transport service chosen as long as terms and conditions of the contract are respected.

2.3 Data Collection: The Revealed Preference Survey and the ASP Experiment

Once the participants and the geographical context to be covered by the study were identified, the data was collected in two steps. In the first phase a revealed preference survey was carried out – through the use of a questionnaire – to identify potential participants to the second stage and to obtain data on actual choices used in selecting a "typical" transport for customising the design of the ASP experiment. In the second phase, the ASP experiment was carried out on a sub-sample of the freight forwarding agencies that participated in the revealed preference survey. The main reason for performing a stated preference experiment, in this context, was the need to test the introduction of a new maritime transport service – on the route of interest for the respondent – alternative to the transport service currently chosen. The final sample constitutes the pilot group, and the estimations are based on the collected database.

2.3.1 The First Phase – The Questionnaire

The aim of the first phase of the interview was to determine whether the company was appropriate for the study and whether it was useful to include it in the second phase of data collection. Inclusion, in fact, depended not only on the willingness of the company to participate but also on its geographical coverage and on the type of traffic it served. In order to compare surface and sea transport it was necessary to identify operators that could consider the hypothetical alternative feasible, given the characteristics of their traffic. For instance, including companies serving the route from northern Italy to Sardinia would not be appropriate as no surface alternatives could be considered viable. Similarly, it would not be appropriate to include in the analysis those serving the routes Turin to Trieste since no sea alternative would be practicable. This part of the study was functional to the second part, the stated preference experiment.

The questionnaire elaborated contained questions directed at acquiring basic facts (products, destinations, typical modes, and so on) on the company's activity and dimension and to understand its actual commodity and geographical coverage. A specific question was included in order to understand the role of the respondent in the organisation of the transport service, the characteristics of the contract and the level of independency from the producer in choosing the transport service. In particular, a section of the questionnaire was dedicated to the definition of the "typical" transport carried out by the company useful for customising the ASP experiment to the company in the context of maritime transport.

The sample has been obtained from the 165 freight forwarding companies belonging to the association of freight-forwarders related to the port of Genoa. About 20% of the companies did not reply to a first telephone contact (34 companies) and, of the remaining, about 15% affirmed of not having a stable working premise in the area of interest (18 companies) and about 10% had the same management as others in the sample (14). The relevant population was thus reduced to 99 units. Of these, about 39% declared that they were not interested in participating (38) without giving additional information and about 25% (25) declared they were not interested in participating as they specialised only in surface transport or had a geographical coverage which was not compatible with maritime transport. The questionnaire was thus sent to the remaining 36 companies (36% of the relevant population). The overall response rate, although limited with respect to the total population, was relatively good with respect to the restricted group of freight forwarders identified as potentially suitable for the interview: 18 companies out of the 36 contacted replied (50%)[9]. From the information collected it appeared that only about 80% of the respondents could be fit for continuing with the second part of the study (14); however, at this stage, only 7 gave immediate availability to continue with the experiment (50%)[10].

2.3.2 The Second Phase – The Experiment

The second phase of the study, which followed a thorough pre-test of all instruments, consisted in an interactive conjoint analysis interview carried out with the managers responsible for the mode choice for the companies participating in the pilot study. The "ASP experiment" was carried out with the support of a portable computer and software which presented a consistent, on-screen, series of scenarios adapting to the respondents' choices.

The interviewing process is the following. On the first screen the respondent is asked to confirm the information on the "typical" transport operation performed by the company acquired through the revealed preference survey. The information is then used to customise the "current choice" of the respondent which becomes the "reference option" and does not change for the whole experiment.

On the basis of the relevant literature[11] and the outcome of the revealed preference survey, four variables are identified as most significant in depicting the transport service:

- price (P), i.e. out-of-pocket cost of transport, including loading and unloading;
- time (T), i.e. door-to-door transit time, including loading and unloading;
- reliability (R), i.e. as % of deliveries as scheduled;
- frequency (F), i.e. as % of service per week offered by the carrier.

The current choice, which consists of a value for each of the four service attributes identified, is reported at each iteration on the left-hand side of the screen, column A, and it is automatically assigned a rating of 100. It is assumed that among the existing alternatives, this is the preferred one, and thus it represents the operator current utility level.

From the second screen and for each subsequent iteration, two more options – B and C – appear next to column A. They report hypothetical alternatives which are

[9] For a detailed illustration of the outcome of the analysis of the data retrieved through the questionnaires see: Bergantino and Bolis (2002 e 2005) and Bergantino et al. (2005).

[10] Although a larger sample would have been desirable, even for the pilot study sampling costs are considerable and organising the meetings quite burdensome and time consuming. Interviews with relevant decision makers have to be agreed upon, set up, often postponed and have rarely been short enough to permit more than one to be conducted on the same day. Nevertheless, the interviewing process is still going on and, at the time of revising this paper, the companies contacted have significantly increased, generating a much larger dataset. Preliminary analysis of the integrated dataset show consistency of the results with the outcome of this first pilot study, which took place in September 2002.

[11] Among others, Fowkes and Tweddle (1996, 1997), Bolis and Maggi (1999), de Jong (2000), Maier and Bergman (2001, 2002), Fowkes and Shinghal (2002) and Danielis and Rotaris (2002). Extremely interesting is the ranking of the attributes most commonly used in analysing transport demand and users' preferences contained in the detailed survey of Cullinane and Toy (2000).

automatically generated by the software and which are characterised by differing values of their service attributes. Column B always refers to the same mode of transport of the "typical" transport defined by the respondent (column A) while column C refers to a different mode of transport. The alternative mode of transport we propose across all experiments is always "maritime ro-ro service". In our experiment, thus, the mode is not just another service attribute and its estimated value allows us to verify weather there would be an *a priori* preclusion for maritime transport.

The value of the four service attributes of each alternative are determined as follows:

- the first time the alternatives are presented (second screen), the information is taken on the basis of the known characteristics of the firms' original transport service in terms of percentages (e.g. % discount or increase in price, % of shipments currently arriving on time, etc.)
- for the subsequent iterations, on the basis of the choices reported each time by the respondent.

In every repetition of the experiment, the hypothetical alternatives presented in column B and C thus change: new computer generated alternatives are presented and the respondent is asked to rank the two alternatives against option A on the basis of the value he/she assigns to the "new" service.

In choosing the rating, the respondent has to use a value scale carefully illustrated by the interviewer. This ranges between 0 and 200[12]. The iterations continue until, for each variable in turn – starting with price –, indifference is reached. In other words, once variations in prices as a function of the rating given by the respondent in the previous iteration do not lead to a variation in the rating, the new screen presents options in which the remaining attributes change values following the same procedures. The process continues until convergence is found for all attributes or at the 20th iteration[13].

3. Data Analysis and Estimation Methodology

Given the characteristics of the experiment, the formulation of the two alternatives, and respondents' choices, each answer given during the experiment is taken as a separate observation. The database is thus made up of 239 observations, an average of 34 observations per respondent.

3.1 Descriptive Statistics

The sample used for the estimation was obtained using the observations gathered during the interviews. Table 1 contains the main characteristics of the data collected

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[12] It is extremely important that the respondent rank options in their desired order, having a clear understanding of the scaling, so to indicate as accurately as possible their strength of preference (Tweedle et al. 1995).

[13] Each iteration generates two responses therefore, in the case that all 20 iterations are run, we would obtain 40 observations by each respondent.

with regards to the "typical" transport services described by each respondent and used as the benchmark for the experiment (column A).

The shipment generally carried out by the "average" company participating in the pilot study lasts two days, it is relatively frequent (every 2.5 days), it is delivered at the expected time more than 80% of the time and costs about 1.3 euro per kilometre. The data collected seems to be relatively coherent across the seven cases.

Table 1: "Typical" transport (average values).

Variable	*Measurement unit*	*Mean*	*Min*	*Max*
Price	(euro)	1,573	1,215	2,350
Time	(hours)	56	50	90
Reliability	(%)	84	50	100
Frequency	(times x month)	12	8	40
Mean length	(km)	1,143	800	2,000

Table 2 shows the mean and the median values of the hypothetical offers presented to the seven respondents. Interestingly, although both mean and median values of the variables Time, Reliability and Frequency are all below the values of the current option, the mean value of the rating is always above 100 (the rating of the reference alternative, the "typical" transport): the shippers always prefer the new services offered. It therefore seems that the savings in cost more than compensate for the reduction in the other attributes and that there is no mode-specific preclusion.

The mean and the median of the difference between the value for each attribute of current service and the hypothetical alternative is shown in Table 3. Across all experiments, the hypothetical services offered a mean discount of about 35%, a mean reduction in travel time of about 4 hours, a mean decrease in reliability of 3,6% and, finally, a mean reduction of frequency corresponding to a service supplied about four times less per month. The mean probability of choosing the alternative service is about 50%.

Table 2: Hypothetical offers: mean values of service attributes.

	Cost (Euro)	*Cost (Index)*	*Time*	*Reliability*	*Freq*	*Rating*
Mean	994.2	60.3	60.5	81.7	12.5	105.8
Median	935.2	57.5	64.0	81.0	8.0	110.0

Number of observations: 239.

Table 3: Hypothetical offers: mean values of the difference in service attributes.

	DiffCostindex	*DiffTime*	*DiffRelia*	*DiffFreq*	*Pa*
Mean	21.3	–2.9	–3.9	2.5	0.5
Median	21.6	0.0	0.0	..1	0.5

Number of observations: 239.

It can be seen that the options presented have been considered unacceptable seven times and that all the zero-values are concentrated in the first experiment (see below). From the raw data it is possible to see that these values are related to changes in the level of reliability: the respondent considered the levels of reliability of the hypothetical offers to be too low, notwithstanding any compensatory decrease in price. The respondent considered reliability an essential attribute of the transport service and any alternative transport service which implied significant changes in the level currently guaranteed represented, for her, a non-viable option. As it can be seen, the remaining ratings indicate that convergence was generally found relatively easily.

3.2 Estimation Results

The estimation has been carried out separately for each company in order to avoid estimation problems linked to the well-known problem of repeated and non independent observations[14]. The procedure chosen to estimate the empirical model is the Tobit ML estimator[15]. The dataset, in fact, contains a number of zero values corresponding to those alternatives which, given the value of their attributes, have received a rating of zero. Since we can assume that those zero values correspond, in principle, to cases in which the latent variable – the indirect utility – might take negative values (i.e. unacceptable levels of reliability which would compromise the respondent activity), we can treat the zeros as a result of censoring and non-observability and thus apply the Tobit estimator.

The results of the estimation are shown in Table 4.

Table 4: Estimation results on ASP data.

	Case 1	*Case 2*	*Case 3*	*Case 4*	*Case 5*	*Case 6*	*Case 7*	*Exp. Sign*
Intercept	1,29	-15,61**	-7,67	-4,68	-9,15	12,58	-9,79*	+
Cost	-0,48**	-1,13**	-0,74**	-1,35**	-1,11**	-1,57**	-0,99**	-
Time	0,70	-0,13**	-1,18*	-1,56*	0,81*	-1,14**	-0,97*	-
Reliability	1,41	5,42*	1,99*	1,64*	-0,18	6,11*	1,57	+
Frequency	1,18**	-0,71	7,13**	10,13**	9,90**	6,29**	12,99*	+
Use of ro-ro	-9,11	15,61	-22,64*	8,05	-12,40	10,57*	14,59*	
Adj. ρ2	15%	49%	28%	59%	54%	48%	39%	
N. obs.	41	27	33	31	35	41	31	239

*=5% ; **=10%

All coefficients (β_i) refer to the effect of a change in the respective variable (i) on the respondent's utility (rating). The coefficients of cost, time, and frequency are generally significantly different from zero. In particular, the coefficient of the variable cost is always significant at the 10% level with an expected negative coefficient. Intuitively, in fact, an increase in cost generates a decrease in the respondents' utility. Frequency and time also have, in general, the expected positive sign as an increase in the difference in frequency and journey time between the current option (A) and the alternative (i = B or C) is likely to have a negative impact on the probability of continuing to choose the current service. The only exceptions are for frequency, case 2, and for time, case 1 and case 5. For the first two cases, however, the coefficients are not statistically different from zero.

Given the focus of our study, of particular relevance is the dummy ro-ro, which should pick up the valuation of the willingness to use the maritime mode. Although the

[14] On the issue of how to tackle the issue in a particular context, the reader is referred to Maier and Bergman (2001, 2002). Although the solutions they adopt are valid and would be relatively easy to apply, in this particular pilot study, given the limited size of the database, we prefer to proceed with separate estimations.

[15] For greater details on the estimation procedure, the reader is referred to Bergantino et al. (2005).

coefficient takes quite differing values among the different case studies, it is generally not significantly different from zero. Except for case 3, for which the parameter is negative and significantly different from zero, it is possible to infer that there is no "a priori" reluctance of the respondents to use ro-ro services. In particular, freight forwarders in the pilot study do not seem to have strong preferences either way.

From Table 4 it can be noted also that, in general, the coefficients have very low values for all the variables and for all case studies. This implies that the marginal impact of a change in a variable on the propensity to change from the current solution to a hypothetical one is small. The respective elasticities would thus be small as well (see also Bolis and Maggi 1999).

In Table 5 we report the monetary valuations of tradeoffs (MVT) between attributes. For each attribute (i), the values are obtained as the ratio of its parameter estimates (β_i) to the cost parameter estimate (β_c).

$$MVT_{ic} = \frac{\beta_i}{\beta_c} \tag{1}$$

Table 5: Trade-off ratios of transport service attributes to cost (absolute values – in Euro per Ton.).

Value	*Case 1*	*Case 2*	*Case 3*	*Case 4*	*Case 5*	*Case 6*	*Case 7*	*Corrected average ***
VOT	(–1.44)	0.11	1.60	1.16	–0.73	0.73	0.98	0.64
VOR	(–2.92)	–4.80	–2.70	–1.22	(–0.16)	-3.89	(-1.59)	-3.15
VOF	–2.44	(0.63)	–9.68	–7.52	– 8.95	-4.01	-13.12	-7.61

[a]The values in parenthesis are not significantly different from zero at the 5% confidence level.
[b]The corrected average includes only the values of the trade-off relative to coefficients which are significantly different from zero, at least at the 5% confidence level.

The values in parenthesis refer to parameters which are not significantly different from zero at least at the 5% confidence level. The corrected average is calculated excluding values which are not significantly different from zero.

Each column of Table 5 reports the amount of money that the respondent would be willing to pay (in case of a positive value) or to receive as compensation (in case of a negative value) for a one-unit variation in the specific service attribute (MVT). The ratio of the service attributes to the cost coefficient yields, in fact, the monetary values of an attribute at the margin and hence gives an idea of how changes in attributes are traded off against a monetary change in transport costs. In the case of time this is the Value of Time (VOT), in the case of reliability and frequency this is Value of Reliability (VOR) and of Frequency (VOF), respectively. As can be seen, an hour reduction of journey time is on average valued 0.44 euro per ton, while a 1% reduction in reliability would require a compensation of almost 3 euro per ton, and a one step reduction in the frequency supplied would require just above 7 euro per ton[16].

While the values of both VOR and VOF are relatively high for most cases, in general the VOT is comparatively low. In general, it seems that for the sample analysed, frequency is the most precious attribute of the service required: this is true for cases 3 to 5 in particular. For these operators, the willingness to pay for an increase of frequency is significantly greater than for changes in any of the other variables. In particular, in case

[16] The reduction in frequency of services varies between twice daily (upper value) and once every two weeks (lower value).

5, the willingness to pay for frequency is more than tenfold the value related to overall journey time. Moreover, the lowest value, corresponding to case 2, is not statistically significant.

Although the sample considered is extremely small and not representative of the category, it is interesting to note that, as expected, freight forwarders tend to give a higher value to factors which enlarge their freedom of choice and the regularity of service than to those elements, like time of journey, which are more easily taken into account in planning their activity.

3.3 Brief description of the case studies

Given the limited amount of data collected in this first pilot study, in order to gain a deeper understanding of the results that are presented in the next section and to place the main findings into the appropriate context, in this section we discuss the outcome of the seven experiments in the light of the general characteristics of the forwarding companies obtained through both the questionnaire and the direct interviews.

CASE 1

Typical Transport: From: Parma (I) To Badaioz (F) ; Via: Moncenisio; Distance: 1500 km; Volume: 60 m^3 ; Mode: road; Transport performed by: road haulier; Shipments per Year: 20 (every two weeks). Product Transported: machinery Product value/consignment: 100000 Euro; Transport Cost/consignment: 1125 Euro.

Forwarding agent 1 operates mainly for firms producing machinery and its main markets are France and Spain. It does not perform the transport itself but contracts it out to well-known road haulers or shipping companies; the concern for granting his direct customers the quality of service required induces the respondent to work with a level of reliability of 100% and thus different levels of reliability become not relevant. Apart from cost, the only service attribute which appears significant for case 1 is frequency (VOT and VOR - not significant; VOF 2.5 Euro for 1 additional shipment/months).

CASE 2

Typical Transport: From: Guastalla (I) To Barcellona (E); Via: sea; Distance: 900 km; Volume: 25/26 tons; Mode: roro; Transport performed by: the firm; Shipments per Year: 500 (two each days). Product Transported: steel tube Product value/consignment: 75000 Euro; Transport Cost/consignment: 1175 Euro

This is a very important Italian carrier, leader in the national and international markets. Along this route the company operates by sea, and the transport manager evaluates this mode of transport as very uncertain by definition: the company, when choosing to use maritime services, seems to take into account the fact that a one-day delay in consignment has to be expected and places high value on reliability (VOR takes, in fact, the highest value of the sample). VOF is not significantly different from zero while VOT, although significant, has an extremely low value (12 cents per ton per hour); the lowest of our sample. The latter is a clear indication of the way ro-ro transport is perceived. Operators are quite willing to adopt it for shipments which do not require high frequency of service nor low travel time: both characteristics which can be taken account of while planning the operation. They, however, are less likely to accept failures in reliability levels. Respondent 2 is willing to pay almost 5 euros for improvements in 1% reliability for ton shipped.

CASE 3

Typical Transport: From: Udine (I); To Tallin (FIN); Via: Germany; Distance: 2000 km; Volume: 45 m^3; Mode: road; Transport performed by: road hualier; Shipments per Year: 100; Product Transported: machinery; Product value/consignment: 50000 Euro; Transport Cost/consignment: 1750 Euro

As for case 1, this forwarding agent does not perform the services in-house. It operates mainly with shipping companies; in fact, about 95% of his shipments are performed by sea (equivalent to 1500 shipment per year) and only 5% by road. It is specialised in the transport of machinery. As in case 1, for the company it is very important work with "well-known" shipping companies or road haulers. It is mainly for this reason that we have noted credibility problems when performing the experiment: "we can't evaluate a service if we don't really know who is going to carry it out!". The estimation outcome, are, however, quite interesting: Respondent 3 shows the highest willingness to pay for a variation improving travel time, the second highest for the possibility to be granted the availability of an additional shipment per month. Also the value of reliability is relatively high (VOT 1,6 euro; VOR 2,7 and VOF 9,6 euros). All the estimated coefficients are significant.

CASE 4

Typical Transport: From: Goole (GB); To Brescia (I); Via: France; Distance: 1000 km; Volume: 24 tons; Mode: road; Transport performed by: road haulier; Shipments per Year: 100; Product Transported: Refractory materials; Product value/consignment: 25000 Euro; Transport Cost/consignment: 700 Euro

This shipping company operates only on international markets, mainly Great Britain/England and the U.S. The availability of the services along these routes, where little or no alternatives exist, is very important. From the estimation it appears, in fact, that the respondent places a high value on frequency (VOF 7.5 euro per ton), while it is less concerned with journey time and reliability (VOT 1,16 and VOR 1,2).

CASE 5

Typical Transport: From: Milan (I);To Barcelona (E); Distance: 900 km; Volume: 8 tons; Mode: road; Transport performed by: road hauler; Shipments per Year: 100; Product Transported: furniture Product value/consignment: 50000 Euro; Transport Cost/consignment: 1500 Euro

This company operates mainly on the Spanish market; there is no evidence of a modal preference and during the interview the respondent stated that when using maritime transport services, time is not very important: "one additional day of travel time is not so influential in the modal choice process of the firm". On the contrary, frequency is very relevant, as the company serves with regularity one main market. The estimated coefficients confirm the statements of the director of the company: the respondent's VOF is the most relevant service attribute (VOF - 8.92 euro per ton for one more shipment per month), while VOR is not significantly different from zero. The valuation of journey time seems to be negative for respondent 5: the magnitude of the coefficient is, however, relative small.

CASE 6

Typical Transport: From: Bari (I) To Parma (IT); Via: Adriatica; Distance: 800 km; Volume: 30 m^3 ; Mode: road; Transport performed by: road haulier; Shipments per Year: 40 (every week). Product Transported: food: 10000 Euro; Transport Cost/consignment: 750 Euro.

This forwarding agent operates mainly for firms producing food products and its main markets are south of Italy. It does not perform the transport itself but contracts it out to small road haulers; the concern for granting his direct customers the quality of service required induces the respondent to work with a high level of reliability (100%) and frequency. The respondent has stated that he would not be interested in any level of reliability different that 100%. Reliability and frequency are thus the most relevant attribute of the transport service. His willingness to pay/accept is, however, generally more limited than the other respondent.

CASE 7

Typical Transport: From: Foggia (I) To Milan (IT); Via: Adriatica; Distance: 900 km; Volume: 50 m^3; Mode: road; Transport performed by: road haulier; Shipments per Year: 25 (every two weeks). Product Transported: machinery Product value/consignment: 100000 Euro; Transport Cost/consignment: 2000 Euro.

This forwarding agent operates mainly for firms producing machinery and its main Italian markets are in the north of Italy. It does not perform the transport itself but contracts it out to either road haulers, train operating companies, shipping companies; His main concern seems to rest with reliability; he cannot take into consideration any variation of the current level of reliability as he generally forwards component parts of mechanical systems. The respondent valuation come out explicitly from the estimation: the concern with time is very limited (VOT 0,98), frequency of service is, instead, extremely highly valued, while reliability appears not significant. The respondent has not accepted any variation if reliability levels during the interview.

3.4 Comparing the Preliminary Results of the Pilot Study with Those of Other European Studies: A Brief Comment

As it had been anticipated it would be interesting to compare the outcome of our analysis with that of studies carried out on the preferences of producers in order to understand whether there are significant differences among the two groups of transport service users. Although a comparison between the absolute values assigned to the single service attributes by the respondents of different studies might be quite difficult to carry out given the different approaches used (also in the definition of the specific variables), a comparison of the relative ranking yields interesting insights. Some common traits, in fact, emerge: as can be seen from Table 6, which reports the relative ranking of the estimated values of the most relevant variables taken from a selection of recent European studies, there seems to be agreement in assigning the lowest value to the variable time among the three main service attributes considered.

Table 6. Ranking of the values of time, reliability and frequency of a selection of European studies (A = higher value between time, reliability and frequency).

Studies	*VOT*	*VOR*	*VOF*
Maier and Bergman (2002)	C	A	B
Danielies and Rotaris (2002)	C	A	B
Bolis and Maggi (2002, 2003)	B	A	C
Our study	C	B	A

The findings on the relative weight of trade-off ratios of our pilot study seem thus in line with the outcomes of similar research carried out in other European contexts. In particular, the results of our study show that reliability and frequency are the two key determinants in users' choice of transport mode. Just as producers, freight forwarders are, thus, more concerned with reliability and frequency than with the duration of the trip. However, in our study, in contrast with the other studies, the relative importance of these two attributes are reversed, with the former assuming a greater weight.

The outcome is not unexpected and can be easily justified: although with all the drawbacks of the exiguity of the sample, our study, focussing on the choice of maritime transport versus currently used alternatives, has highlighted the specificity of the context. In transport services performed by sea the availability of regular transport – i.e. a regular frequency of the service demanded – becomes a strong decisional factor for firms which have to abandon the currently used mode of transport. In this context, reliability assumes a secondary role: a decrease in reliability is easily taken into account by price changes and by contractual agreements. The unavailability of service when needed would, instead, completely preclude the use of the mode. Moreover, being a freight forwarder an intermediary in the transport process, he sees the possibility of responding to the needs of the client by granting the availability of the services when required as a relevant aspect of the quality of the service he himself offers.

Increases in journey time, which assume an extremely low value, are considered strictly linked with the maritime alternative and are immediately internalised in the reorganisation of the transport service adopted when deciding to view the ro-ro alternative as viable.

4. Concluding Remarks

In this paper we have presented preliminary evidence from a pilot study carried out with the primary objective of testing the validity of adaptive conjoint data collecting methods in analysing operators' preferences when redirecting current on-land transport services to a hypothetical maritime ro-ro alternative. Secondary objectives, though not less important, have been to obtain a preliminary rating of the transport attributes included in the stated preference experiment and a first on-the-field test of the soundness of the selection carried out with respect to the analysis of the maritime ro-ro context. Also, it has been a test of the appropriateness of selecting as respondents freight forwarders in their vest of transport service users.

The application has involved a small sample of freight forwarders localised in the area of influence of the port of Genoa. Freight forwarders have been preferred to producers in order to gain insights from a wider spectrum of possible uses and, at the same time, to verify weather the preferences of this set of users would differ widely from those of the producers. Choosing freight-forwarding agencies has allowed us to intercept information from a sector of the transport industry which accounts, on average, for more than half of the transport decisions, as outsourcing of transport operations is spreading rapidly. At the same time, it has allowed us to obtain a sample which, although small, is homogeneous as to the type of activity carried out by the respondents and their knowledge endowment. Given the limited resources available, selecting producers would have limited the scope of the analysis to a specific production sector or excessively constrained the dimension of the dataset for each industrial sector. Although the objective function of the freight forwarder would necessarily differ from that of the producer, the recent evolution of the market and of the contractual agreements in force would generally place the freight forwarder in a position to be the residual claimant to any cost-quality advantages obtained. In any case, this is true for the sample interviewed.

The current study has allowed us to test our methodology and the strategies adopted for carrying out the experiment. The specificity of the design used has been to always characterise the alternative service as ro-ro. In so doing we tried to stimulate, during the experiment, an explicit focus on such mode. Although the results presented in this paper relate only to a very limited group of potential users with obvious consequences on sample representativeness, some preliminary considerations on the outcome can be drawn. We are aware that, in order to validate the results, it would be necessary to compare them with the final outcomes of a follow-up research project currently being carried out involving freight forwarders localised in northern and in southern Italy.

The study seems to confirm that, as expected, adapted stated preference techniques represent a valid option to estimate the attitude of operators for maritime ro-ro transport services. Overall, initial evidence is encouraging and offers some understanding of the determinants of the maritime transport choice.

First of all, the data collected seems to indicate no *a priori* preclusion of the maritime alternative and, in particular ro-ro services, on the part of operators. The valuations placed on the attributes of the transport services by the freight forwarding companies interviewed are generally consistent. The empirical evidence confirms that freight rates are not the only determinant of modal choice, but that in choosing the sea other factors play a relevant role as well. Most notably, and in line with the results of other studies, reliability and frequency seem to be the key factors in the choice of the transport service alternative. However, between the two attributes, in contrast with other studies concentrating on land transport and producer responses, the ranking of reliability and frequency are inverted. When evaluating the maritime alternative, freight forwarders, in fact, seem to assign a higher ranking to frequency than to reliability.

According to our estimation – which, however, due to the limited database should be taken with the appropriate scepticism – freight-forwarders seem to value a 1% improvement in reliability at about 3 euro per ton and a variation in frequency just above 7 euro per ton. The difference in the findings could be easily justified on the basis of two elements: first, a single producer might consider a change in the frequency of service easier to adapt to than a change in its level of reliability; secondly, a freight forwarder, who often aggregates more than one shipment, might give a higher weight to frequency of service since it contributes more than reliability to solve transport coordination problems and to respond faster to different requests by clients. Journey time, in line with other studies, is significantly less valuable than the time lost for low levels of reliability or for low frequencies. From the sample it appears that it is unanimously considered to be the least relevant attribute: the value of time is calculated to be, on average, about 50 cents per ton.

In conclusion, taking the outcome of the preliminary estimation into consideration, it would appear that in order to improve the use of the maritime ro/ro, it is important focus on actions which improve the reliability and the frequency of service.

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Evaluation of quality attributes in the freight transport market. Stated preference experiments in Switzerland

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Abstract

Globalization and European integration increase the claim for better quality in freight transport and logistics services. The paper focuses on the evaluation of different quality attributes of transport services in a significant segment in the Swiss freight market. The paper is based on conjoint analysis, generated by discrete binary choices between alternatives of hypothetical transport services, described by a combination of four attributes articulated on different levels. The estimated results confirm the high importance of punctuality and avoidance of damages. It could also show the statistically significant relation of the declining value of time with increasing distance.

Keywords: Freight transport; Stated preference; Discrete choice model; Value of time; Switzerland.

1. Introduction[1]

In the last twenty years, globalization and European integration have led to a substantial increase of freight transport that was further fuelled by cheaper communication and decreasing transport costs. This process is accompanied by a structural change towards lighter and more voluminous freight goods, generally shipped at higher frequency. New production concepts and spatial production networks have enhanced the significance of logistics. For this reason logistics services are usually outsourced to specialized companies. At the same time new patterns in production and in the distribution process generate demand for high quality transport and logistics services.

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So far, the empirical transport research on demand behaviour was either focused on mode choice or the time aspect or the value of travel time saving. Compared to passenger transport stated preference analysis in the freight market is still in its infancy as underlined recently by Regan and Garrido (2001). This can be explained to a certain extend by the difficulties to create a significant sample and to deal with the extreme complexity. An interesting overview with national case studies can be found in Danielis (2002). In Switzerland, no representative national analysis on the value of time in freight transport is available, with the exception of one first attempt regarding the transalpine freight market (Maggi, Bolis, 1999). However, besides time, other quality attributes, such as punctuality and avoidance of damages, become more and more important in the context of present logistics services.

The main goal of the research project was to analyse and to monetize the significance of quality attributes in the freight transport market. The evaluation of the key quality attributes of freight transport services is based on a stated-preference analysis. The paper is focused on a specific freight market segment and therefore its results are not representative for the entire Swiss freight market. In spite of this limitation the following results with a monetary valuation of quality attributes represent a first step and input towards the building up of a framework for cost-benefit analysis of new infrastructure investments or other investments to improve the traffic conditions on Swiss roads. A critical analysis of the role and significance of the value of travel time savings in cost-benefit analysis and of the tendency to overestimate the value of time is given by Bergkvist (2001).

In Section 2 we introduce shortly the method of conjoint analysis or stated preference (commonly used as a synonym) and the sampling approach, focussed on a significant market segment, followed by a description of the companies and the typical transport relations, which constitute the reference of the experiments in Section 3. In Section 4 we present the results of the statistical analysis of the empirical data. In the final Section 5 we draw some conclusions.

2. Method and investigated market segment

The research project is based on a standardised interview and a conjoint – or stated preference analysis for hypothetical transport services based on a computer experiment. The experiment consistently refers to a typical transport-relation chosen by the logistics managers. The logistics context of the transport relation was described by four variables, whereas the hypothetical transport services were characterized by four attributes (price, time, punctuality and avoidance of damage) according to the literature. Hence, the experiment was based on the following attributes and attribute levels.

Table 1: Quality attributes and their levels.

Transport service				Logistics context		
Price	Avoidance of damage	Time	Punct-uality	Notice time	Mode	Frequency
-20.0%	98%	-20.0%	98%	Immediately	Truck	Daily
-10.0%	96%	-10.0%	95%	Same day	Rail	Every 2 days
0.0%	94%	0.0%	90%	Next day	combined	Every 4 days
+ 10.0%		+ 10.0%				weekly
+ 20.0%		+ 20.0%				

The four variables at the right hand side of the table, where used during the interview, introducing the experiment, in order to characterize the logistics context of the chosen typical transport relation. Originally, the logistics context was described by four different variables. The fourth variable referred to the possibility to trace and track the shipments. After all experiments it had to be recognised that this variable didn't discriminate the different shippers and therefore could help to improve the model. Meanwhile, the variables to describe the transport service were fully integrated in the experiment. The scale for the different levels for price and time is large compared to real offers. The logistics managers after some explanations accepted the hypothetical character of these values. However, during the preparation of the experiment they stressed, that a similar scale was not accepted for the other due variables. In fact, several of the interviewed logistics managers during the pre-test insisted to consider an even smaller scale, since the values refer to the percentage transport volume of the typical transports relation consigned with these characteristics.

A principle assumption of the research project regards the relation between the transport service and the logistics context. The underlying hypothesis was that logistics managers evaluate the transport services in the context of the logistics context of a specific transport which may vary within the same company. Hence the evaluation of the transport service quality is not necessarily depending on the attributes of the company. For a more sophisticated treatment of interaction see Hensher (2003).

After having described the typical transport relation and its logistics context, the logistics managers were faced with the (binary) choice between two alternative and hypothetical transport services, each being defined by a combination of quality attributes at different levels. By the choice they made the logistics managers expressed their preference for one of the two combinations. The experiments were carried out with the commercial software CBC (Choice-Based Conjoint) by Sawthooth, 2003.

Which of the following alternatives would you choose for the typical transport relation?

Transport price	**Price plus 10%**	**Present price**
Damage	**98% undamaged**	**94% undamaged**
Time	**10% longer**	**Present time**
Punctuality	**present**	**95%**

Fig. 1: Example of a binary choice situation.

The basic assumption of the experiment is that the choice of a transport service alternative is based on the linear addition of preferences for single items (partial preferences). During the experiments these choices were repeated twenty times, as a rule for two typical transport relations. The collected data base is constituted by 66 valid experiments and 1320 binary choices, available for the statistical analysis.

In the light of the high expenditure for a stated-preference analysis and computer-based experiment in the transport market, the project had to be restricted to a relevant market segment. Thus, 35 logistics managers of median and large companies of the food and wholesale sector finally agreed to join our sample. However, the logistics operators were asked to choose transport services on the supply - and distribution side using different transport modes for the experiment. Neither forwarders nor transport operators were included in the sample, since the evaluation of the quality aspects is meant to reflect the perspective of the "consumer" of transport services.

3. Descriptive results

The focus of the project was the market segment of wholesale and food. The sample is constituted mainly by medium and large companies. More than fifty percent of the investigated companies had more than 250 employees, exceeding by far the medium size of the Swiss firms. Therefore the sample is not representative for the chosen market segment as far as the company size is concerned. The main concern was to include companies with a wide range of transport requirements and a specialized logistics department with high experience (more than 500 shipments per week), a large number of different articles and a high number of suppliers as well as clients. These companies, however, outsource to a considerable degree logistics services. The tendency to outsource logistics services clearly increases with the declining strategic importance of these services as shown in the following table.

Table 2: Outsourced logistics services.

Logistics services	Number of companies in the sample
Electronic data elaboration	3
Inventory control	5
Storage	10
Quality control	3
Packaging	7
Labelling	6
Transport	33

As a consequence of the high degree of outsourcing of the transport services the analysed companies dispose of relatively few own transport means. The following table indicates the type of transport means and the number of companies in the corresponding categories. The first cell, e.g., indicates that 19 companies do not own one single truck and only 3 companies have more than 50 trucks in their company fleet.

Table 3: Own account transport means.

	0	<9	10-49	>50	Total
Trucks	19	5	7	3	34
Semi-trailer	27	6	0	2	35
Small truck < 3.5 tons	25	8	2	1	36
Swap bodies	25	0	0	0	25
Containers	34	1	0	0	35
Railwaggon	34	0	0	0	34

An essential feature of the whole experiment with the logistics managers regards the typical transport relation. In spite of our relatively homogenous sample, compared to other comparable studies, the variance in the typical transport relations is quite impressive. The following table summarises the most important characteristics of these transport relations.

Table 4: Characteristics of the typical transport relations.

	Minimal value	Mean value	Median value	Maximum value
Weight of transport goods in kg	4	9'100	7'250	26'000
Value of transport good pro kg	0.02	24.6	4	300
Transport costs	8.6	869	580	5'500
Transport time	0.5	48	6	672
Value of shipment in CHF	60	106'500	20'000	2'220'400
Distance in km	18	695	189	8'000

This heterogenity in the chosen transport relations constitutes a major difficulty in the interpretation of the results and makes it particularly difficult to draw general conclusions on the basis of the investigated sample. A problem that can hardly be avoided in the analysis of disaggregated demand behaviour in the freight market. (

4. Discrete choice models and results

The value of time and the monetary values of quality attributes of the variables "punctuality" and "avoidance of damage" are based on an econometric analysis of different formulations of the utility function. They are all based on the assumptions of the random utility theory, where the utility of a choice depends on systematic term (measurable influence by the four variables in the experiment) and an error term.

$$U_{ik} = V_{ik} + \varepsilon_{ik}$$

In present experiment situation the dependent variable on the left hand side of the equation represents a binary choice, between one of the two alternatives on the computer screen. The possible value of this variable is either 0 or 1. The linear regression model for the statistical analysis cannot be applied. Therefore it has to be transformed in two steps, in order to fit the binary values of the dependent variable. The econometric analysis is based on the maximum likelihood method (Urban 1998). The data was analysed with the LIMDEP software package version N-logit 3.0.
The mathematical formulation of the underlying model or utility function of the basic model (Model 1) can be expressed as follows:

$$U = \alpha + \beta_P Price + \beta_T Time + \beta_D Damage + \beta_{Pu} Punctuality + \varepsilon$$

Besides the attributes used in the conjoint-analysis, random parameters and a distance related elasticity parameter for the price variable were introduced, into the model and successfully estimated, according to a recent study by König (2004), whereas no statistically significant relation could be identified between the basic model and the logistics context or characteristics of the companies.

$$U = \beta_{p*}\left(\frac{Transportdistance}{Mean - transportdistance}\right)^{\varepsilon_{Dist}} * Price + \beta_z Time + \beta_s Damage + \beta_{Pu} Punctuality + \varepsilon$$

Table 5: Model estimations with and without elasticity parameter.

Variables	Unit	Entire sample Binomial-Logit	Elasticity-parameter
Price	%	-3.173	-4.106
(t-ratio)		(15.503)	(-20.6713)
Time	%	-.4894	-0.517
		(-3.620)	(-3.79733)
Avoidance of damage	%	41.402	42.523
		(13.974)	(14.2033)
Punctuality	%	28.580	29.375
		(9.994)	(-10.141)
Elasticity parameter			-0.225
			(5.869)
N		1320	1320
Log L		-573.763	-560.030
Log L (0)		-914.081	-914.954
Rho-square		0.369	0.388

All parameter values are statistically significant and present the correct sign. The introduction of an additional model specification with the elasticity parameter could improve the values the single parameters as well as the overall model fit, expressed by the higher value of the Rho-square and log likelihood. Within the results of single models the parameter values can not be compared directly, because they refer to different scales (Urban, 1993).

The figure below, the elasticity parameter of the price variable contributes to showing up the relation between the value of time and the distance.

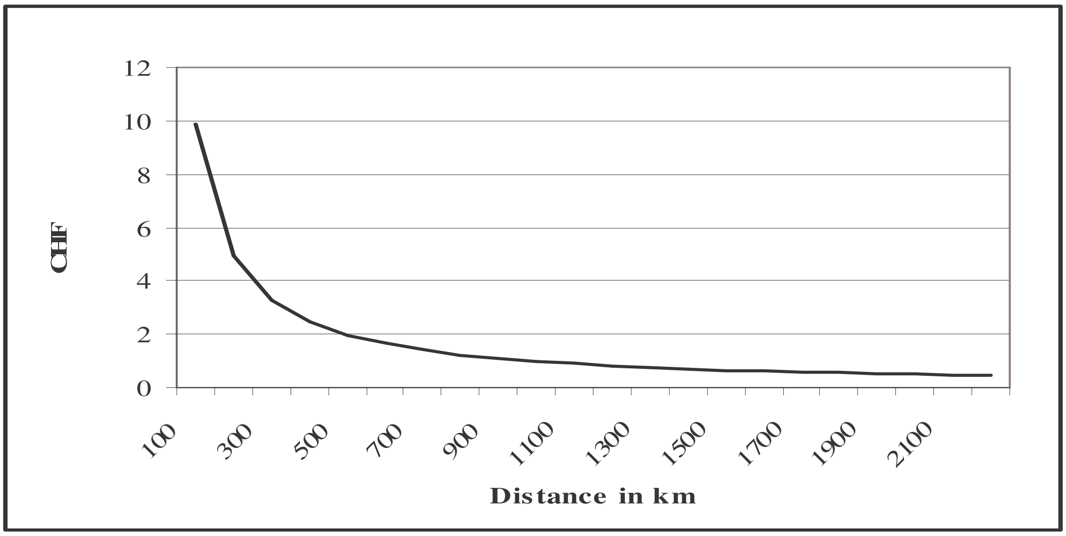

Fig. 2: Calculated relation between the distance and the value of time.

A similar figure emerges for various segments introduced in our sample. It clearly underlines that the value of time sharply decreases with the distance. The segments are based on different criteria such as logistics context, transport mode, transport in the internal, the import and export market, each segment represented by a different mean distance.

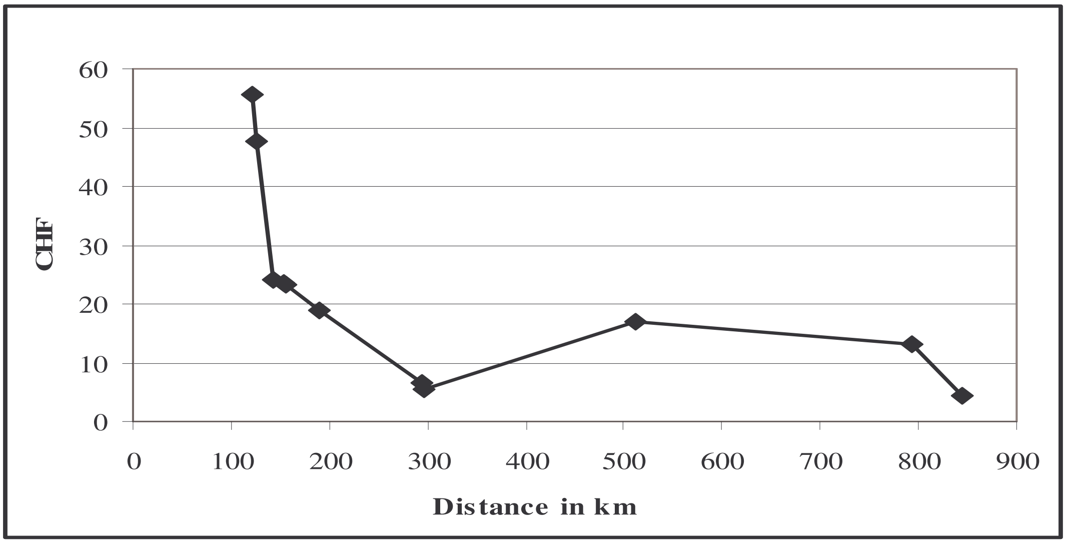

Fig. 3: Value of time for different market segments.

A similar relationship could be identified neither for other quality attributes nor for the value of the freight goods. The monetary values of the three different quality attributes, as used in the SP-experiments, correspond to the declared willingness to pay for an improved quality of transport services for a shipment of 7.25 tons over a distance of 189 km:

Table 6: Monetary value the different service quality aspects.

	Reduction of transport time	Increase of punctuality	Avoidance of damages
Willingness to pay	/ 1 hour	/ 1%	/ 1%
CHF	16.19	48.23	78.01
CHF/Tonne	2.23	6.65	10.76

The estimated value of time must not to be mixed up with the transport operator's costs. The saving of one hour of transport operational costs is worth considerably more than the estimated value of time, which reflects the shipper's perspective and is comparable with the values in international studies. These results cannot be applied to the whole freight transport market for several reasons: in particular, the lack of statistical data, which would bring about a classification of the typical transport relations and help determine to what degree they represent the transport market.

However, the results seem to be in line with the results of similar studies, cited by DeJong (2000), with the exception of Small et al. 1999, a study carried out in the United States. It was not possible to consult the original study and we ignore the precise reference of the study. In any case the indicated values seem to represent an outlier.

Table 7: Selected international studies with value of time estimations.

Authors (Studies)	Year	VOT (in CHF)
Bergkvist/Westin (S)	1998	1.9 - 43.3
Small et al. (USA)	1999	261-400
Bergkvist/Westin (S)	2000	1.5
De Jong et. al. (F)	2001	7.5 – 16.5
DeJong/Rand (NL)	2004	25.3
Mean value in Europe		29.5

Source: DeJong, 2000.

5. Conclusions

The empirical study on the individual demand behaviour of logistics managers and the subsequent model estimation yield interesting results that are new for Switzerland. The study has clearly shown that shippers and their logistics managers evaluate quality attributes such as punctuality and avoidance of damages at least as highly as travel time savings.

An important result refers to the monetary values of the different quality attributes of transport services, which are much higher in the internal market than in the import and export segment, with its clearly longer average distances. The relation between the value of time and distance was confirmed when an elasticity parameter was introduced into the model. This result will have to be taken into account when defining a framework for the cost-benefit analysis of infrastructure investments or other measures for the improvement of road traffic conditions.

The study revealed no statistically significant relations between essential characteristics of the companies and their evaluation of quality attributes. This seems important in so far as the sample refers to a market segment, which is quite homogenous as compared to similar studies. This implies that the differences in the evaluations cannot be traced back to the characteristics of the company but rather stem from differing claims on transport service quality. However, in the scope of this study it is not possible to compare the evaluation of quality attributes among different productive sectors and the study fails to make statements on representative monetary values for the various quality attributes.

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Container terminal handling quality

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Abstract

In any service market, the price/quality relationship is of main importance. In the container terminal handling market, quality is important in attracting and retaining customers. Meeting customer needs and delivering high quality for low costs are critical factors for terminals to be successful. Container transport companies are interested in speed and reliability. The time a ship or barge stays in a port must be minimised, and, therefore, the handling of containers must be executed in a fast and reliable way. The operations at the terminal, after the handling of the containers on and off the ship, must be reliable as well. Quantitative information on container terminal quality is hard to obtain. Container terminals are monitoring their quality levels, but the results are not publicly available. Therefore, a literature survey forms the main input for this paper combined with interviews with terminal operators. The aim of this paper is to offer an operational approach for the measurement of the quality of container terminal services. The central research question is; 'Which are critical performance conditions in terms of quality for container terminals?' For the container terminal sector in Europe, 'reliability' is now the number 1 quality aspect in their transport services (including container terminal handling). Quality levels must meet high standards set by container carriers. Costs, incurred by better quality performance cannot be recovered through higher rates. 'Reliability', in terms of meeting container carriers' demand, is thus a critical performance condition for maritime container terminals. An external performance improvement characteristic might be 'flexibility'. Deep-sea ship arrivals are no easy planning task, as weather influences and other problematic developments make the terminal operator's task more difficult. Through strict contracts, all risks of delays and terminal berth congestion are passed onto the terminal operator. This makes 'flexibility' a critical performance condition. A critical performance condition for continental terminal operators is a 'total service'.

Keywords: Container terminal; Terminal handling market, Quality of service.

1. Introduction

In any service market, the price/quality relationship is of main importance. In the container terminal handling market, quality is important in attracting and retaining customers. In Europe, container carriers do have choices between different container

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ports that can meet their demand. For the terminal operator, this results in the increasing importance of quality and the need to know the needs of (potential) customers. A favourable network position and well-organised processes are no longer sufficient to attract container volumes. Meeting customer needs and delivering high quality for low costs are critical factors. In their supply chain, container carriers are interested in speed and reliability. The time a ship stays in a port must be minimised, and, therefore, the handling of containers must be executed in a fast and reliable way. Minimising the number of damaged or lost containers forms another part of the quality picture. The operations at the terminal, after the handling of the containers on and off the ship, must be reliable as well. Currently, the adoption of innovative handling systems to improve operations has not been signalled in the European container terminal market (Bontekoning, 2002). Quantitative information on container terminal quality is hard to obtain. Container terminals are monitoring their quality levels, but the results are not publicly available. Therefore, a literature survey forms the main input for this paper combined with the interviews with terminal operators. The aim of this paper is to offer an operational approach for the measurement of the quality of container terminal services. The central research question is; 'Which are critical performance conditions in terms of quality for container terminals?' 14 interviews have been carried out in order to offer insight into the actual terminal service quality. For this purpose, the well-known SERVQUAL-model is used. This presents an 'operational' view on the judgement of service quality of container terminals by terminal operators (Parasuraman et al., 1991).

2. Review of quality of services

Definition of service

According to Kotler (1997), a service is any activity or benefit that one party can offer to another that is essentially intangible and does not result in the ownership of anything. Generally, a service can be categorised in terms the following four distinguishing characteristics:

1 intangible;
2 simultaneous production and consumption;
3 heterogeneity;
4 transitory.

Intangible means that 'a service can not fall on your feet' (Grönroos, 1990). Generally, a service is not physical but it is more a 'sort of experience', which means that material possessions do not increase if a service is bought. Intangibility is to be seen as a criterion that varies between 0 and 100 percent. In theory, a pure service is 100 percent intangible, while a pure good is 0 percent intangible or tangible. Simultaneous production and consumption is also referred to as interactive consumption (Lovelock et al., 1981). This means that the consumer needs to be present when the service is produced. In this respect, the consumer is regarded more as a prosumer, i.e. the customer is partly seen also as producer of the service. An example of being a prosumer is an interactive container tracking- and tracing system. The consumer is asked, via the

Internet, to provide specific information about his shipment to the transport carrier. After sending the required information to the transport carrier, the status of his shipment is provided. The container terminal service is special, in the sense that the service is bought by the management of a container carrier (or barge or rail transport company), but the service is 'experienced' by employees who operate the ships, barges or trains. Because of the participation of the customer in the service production process, it is difficult to standardise services. The customer influences the quality of the service. Requiring the presence of customers in the production of the service implies that the factor time increases in importance. Time may be split into objective time (time in minutes/hours/days) and subjective time (perceived time by the customer). For example, many continental terminals monitor the time that trucks spend at the terminal. The aim is to service the trucks within 30 minutes of arrival. The transitory character of services means that the creation of stocks is impossible. This results in an increased importance for capacity management. Management of supply and demand for services ideally results in minimal unused capacity. This applies to both quiet and busy periods (for example, ship congestion when all berths are occupied or when terminal congestion arises). Generally, waiting time is connected with capacity management and ICT-technology. The terminal operator might influence the satisfaction with the waiting time on three levels:

1 *expectations* from the customers about the situation;
2 *tolerance* of the customer to waiting at the agreed time of delivery of the service;
3 *evaluation and valuation* of the waiting itself.

'Terminal congestion' imposes a great threat to the efficient operation especially of maritime container terminals. In Rotterdam, for example, the time between the arrival of the maritime container and inland transport is judged to be too long by some terminal customers. This is partly due to veterinary control and the container scan (Nieuwsblad Transport, 2001). Container scan inspection time may add up to five days for rail transport. Road transport does not face this problem: a scan only takes around 12 minutes. All these container terminal service characteristics are important inputs for the service production process.

Service production process

In the service process, usually the front office of a service organisation interacts directly with customers. This direct interaction is conceded as 'the moment of truth' for the service organisation. The back office is usually not visible for customers. It may be of strategic importance for the service organisation to manipulate the size of its front and/or back office. The conventional service triangle (see Figure 1) consists of three actors (de Vries et al., 1994):

1 the service organisation (back-office);
2 its contact personnel (front-office);
3 its customers.

The production process of a service can be based on a customer-orientation, a competitor- orientation or a market-orientation. In a customer-orientation, the main objective of the producer of the service may be to fulfil customer needs. He can strive to provide a better price/quality service than his competitor (competitor-orientation), or he can provide his service both customer- and competitor-oriented (market-oriented) (Narver and Slater, 1990; Slater and Narver, 1995). A relatively newly distinguished orientation is process-oriented. In this case, the service is seen as part of the whole supply chain and there is an extensive exchange of information between actors in the supply chain in order to be able to perform all services smoothly.

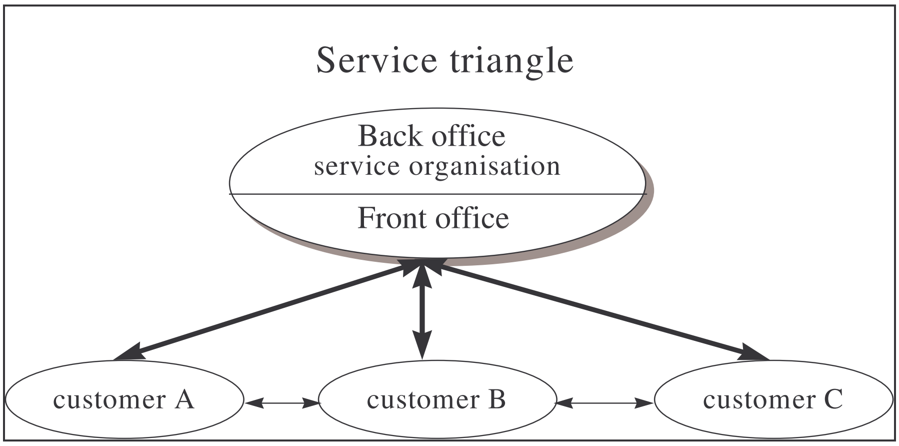

Fig. 1: Conventional service triangle.
Source: Based on de Vries et al., 1994.

If the focus is laid on the relation between the terminal operator and its customers, it can be observed that actually four actors are engaged in the service process. There is: the terminal operator; his personnel; the terminal customer; and, the terminal-customer personnel. Thus, instead of the three actors usually involved in the service process, at the container terminal, one extra actor (the terminal-customer personnel) is engaged in the service production process (see Figures 1 and 2). Thus, at the container terminal, two service production processes can be found: one for the terminal customer and one for the terminal-customer personnel.

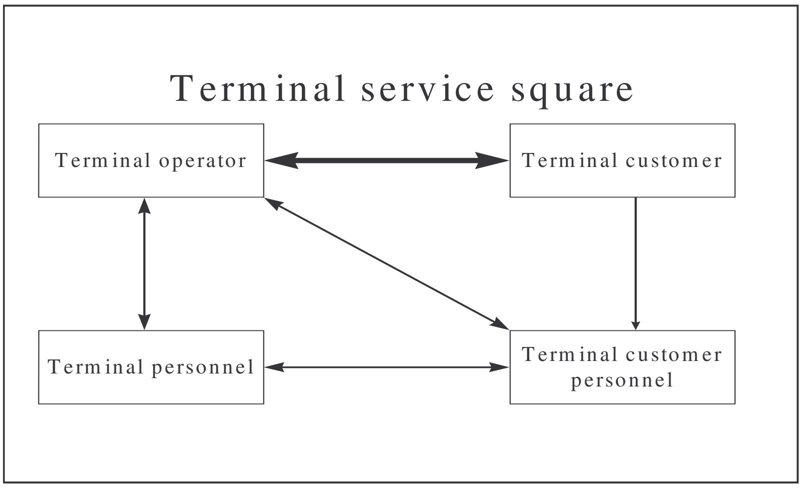

Fig. 2: Terminal service square and actors involved.

History and background of service quality analysis

According to Garvin (1984), four phases in the development of quality can be distinguished: I) inspection; II) statistical quality control; III) integrated quality care; IV) strategic quality management. The approach to quality used in this paper is embedded in marketing research. The user (customer) of terminal services fixes the service quality. Generally, in this approach, service quality is defined as 'the difference between expectation and observation'. Research from Parasuraman, Zeithaml, and Berry (1988) shows five dimensions on which users, in general, judge quality. These five dimensions are:

1 tangible matters (e.g. facilities or personnel);
2 reliability (e.g. ability to perform a reliable and accurate service);
3 responsiveness (e.g. willing to help customers and to perform a service quickly);
4 assurance (e.g. knowledge and courteous personnel);
5 empathy (e.g. care for the individual customer).

It is noteworthy that Grönroos (1990) identified only two dimensions of quality: technical quality and functional quality. Technical quality has to do with 'what service is produced?' Functional quality has to do with 'how is the service produced?' And finally De Vries et al. (1994) define Total Quality Control as 'a targeted system to integrate the aim of all groups within an organisation to develop, maintain, and improve quality, in order to organise service and production as efficiently as possible, leading to a completely satisfied customer'. Total Quality Management (TQM) is purely focused on the requirements of customers. On the personal front, people only go back to restaurants that fully satisfy them. Industrial customers, likewise, have a set of requirements and expectations that must be met by the supplier to create repeat business (Bank, 2000). Industrial customers have the same set of emotions as personal customers to being short-changed, disappointed, or cheated. The industrial customers' response to poor service quality is similar: withdrawal of business and buying elsewhere. In traditional quality management, the focus was on acceptable quality levels, 'react' culture, and reducing defects. In TQM, this is no longer enough. TQM is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organisation (Rampersad, 2001).

In Figure 3, the main features of TQM are given.

Quality can be defined as 'fully satisfying agreed customer requirements at the lowest internal costs' (Bank, 2000). In general, customers perceive terminal services to be low quality, resulting in not completely satisfied customers. Quality management of container terminals is still quite traditional, which is reason enough for an increasing number of container carriers to start operating their own dedicated maritime container terminals. Customers of continental container terminals, dissatisfied with the service quality, might return to using single-mode road transport. When trying to accommodate customer needs, a complicating factor for the continental terminal operator is the wide variety of terminal customers. Almost each terminal customer needs its own terminal service quality performance. Transport research in the EU (IQ, 1997; EU, 1997, TERMINET, 1998) shows the following important quality elements concerning transport: time, reliability, flexibility, qualification, accessibility, control, handling price, frequency, speed, long-term planning, management, and safety and security. A structured approach towards terminal service quality is offered by the SERVQUAL-model (see Sections 4 and 5).

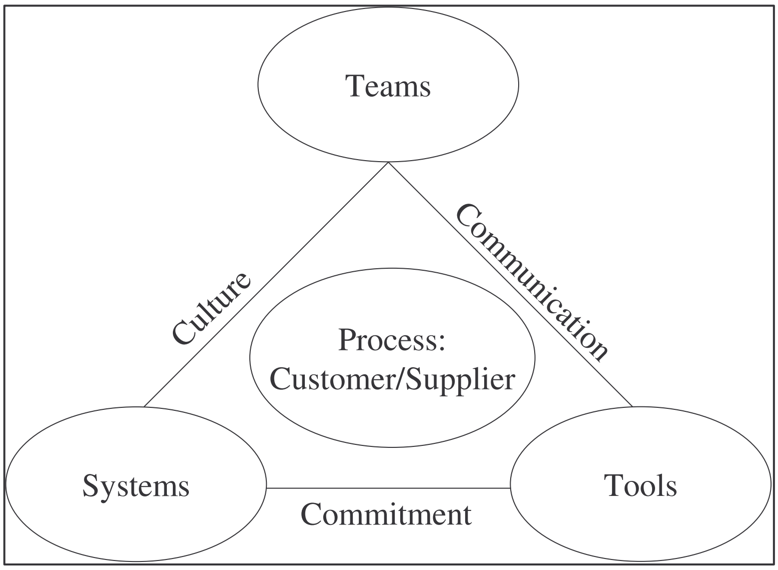

Fig. 3. Total Quality Management Model
Source: Oakland, 1994.

3. Container terminal service quality

Measurement of container terminal services

The measurement of service quality can, in general, be done with regard to three aspects: search, experience, and credence attributes. ‘Search attributes’ are quality features that can be identified by the customer before the purchase of a certain service. ‘Experience attributes’ are features that can only be disclosed during or directly after the consumption of a certain service. Finally, ‘credence attributes’ are features that can not be identified by customers, neither before nor after the consumption of the service. Salient Multi-Attribute Research Technique (SMART) is a well-known research technique to measure service quality (de Vries et al., 1994). SMART enables the identification of service elements that, according to customers, need the highest priority when improving the service. Another research technique is called conjunct research (de Vries et al., 1994). In this technique, in-depth interviews provide the service attributes with the corresponding levels of service. Each attribute is connected with a number of service levels and each customer is asked to evaluate certain imaginary services in terms of these levels. This technique has provided the basis for the interviews with terminal operators.

In order to measure terminal service quality, a distinction must be made between the different terminal service elements. At a container terminal, the single most important activity is the movement of containers, whereas the secondary function is storage. This primary function of a container terminal can be divided into different parts: loading; unloading; and, direct transshipment of containers. Transshipment is the unloading of a

Transport Unit (TU) directly followed by the loading of the TU onto another transport means. Handling is the unloading of a TU followed by the temporary storage of the TU at the terminal, which is followed ultimately by loading the TU onto another transport means for further transport. At a container terminal the following central activities can be found:

1 *ship-oriented services*: discharging the ship, loading the ship, direct transhipment, storage of container/warehousing, and container groupage
2 *yard-oriented services*;
3 *other terminal services*: manufacturing, renting/leasing/selling services, collection/distribution of container, physical transport of container, container monitoring, and other services.

Bowersox et al. (1986) view handling as one of the most costly aspects of logistic channel performance, and thus the objective is to reduce handling operations in the logistic chain to an absolute minimum. This creates an extra dimension concerning quality: there is a tendency to minimise terminal handling to a minimum, stressing the importance of quality even more. The distinction between services is necessary in order to be able to determine which services are important or should be important to the terminal operator. In addition to this, performance measures should be developed to be able to monitor the performance of the terminal with respect to the chosen quality aspects.

Actors in the service process and quality

Besides the services provided the customers are important, because, in the final analysis they must judge the quality of the services offered. If the focus is placed on terminal customers of both maritime and continental terminals, four main groups of customers can be distinguished:

1 container carriers (deep-sea shipping companies);
2 transport companies (rail-, road-, barge-, and short-sea transport companies);
3 importers/exporters (intermediaries, such as stevedores, ship brokers, shipping agents and forwarders);
4 shippers (companies that send and receive the freight).

The main customer groups must be identified in order to be able to determine the weight that must be placed on the judgements of the different groups. The services that are provided can be grouped according to type of customers, importance of different sales categories, type of container (process) or transport mode (network). Usually, terminal operators are not entirely clear about their customers, and therefore offer a broad package of functions for the sake of risk-spreading and widening the operating base (i.e. many potential customers). In the continental terminal market, much is expected from new generation terminals (Bontekoning and Kreutzberger, 2001). These types of terminals are expected to deliver an improvement of the cost-quality ratio of terminal operations (Konings and Kreutzberger, 2001).

The terminal service buying process can be divided into three activities:

1 pre-purchase phase (problem definition, information collection, and evaluation of alternatives);
2 consumption of the terminal service;
3 post-purchase phase (evaluation of the terminal services).

In the pre-purchase phase, the actors are the terminal operator and the terminal customer. Usually, the terminal-customer personnel, the terminal personnel and the terminal operator consume the terminal service. The terminal customer and his personnel execute the evaluation of the service. Generally, the customers' management does not have an obligation to be present in person. The service delivered to the terminal customers is quite homogeneous and there is no need for participation of the terminal customers' management in the service production process. Furthermore, the customer service is intangible, there is no need for simultaneous production and consumption, and the objective terminal transit time is highly important.

Terminal customers and quality

In Figure 4, the main elements influencing, and following from, terminal service quality are depicted. The terminal customer provides the terminal operator with requirements concerning the desired terminal service. In particular, flexibility requirements have been growing in importance during the past years (Kuipers, 1999). The terminal customer consists of two elements: the management (back office) and the employees (front office) who are present when the service is produced at the container terminal. The terminal operator also consists of two sub-elements: front office and back office. This results in four groups that may have different expectations and observations about terminal service quality. This means that both the terminal customer's front- and back office must judge the quality of the terminal service. An additional complicating factor is that for the terminal operator the inclusion of the supply chain (or marketing channel) approach in the quality delivery is extremely important, because it is the channel, not the terminal operator that actually delivers the products and services to the final customers. Without channel coordination, it may be even harder to achieve an adequate terminal service performance level.

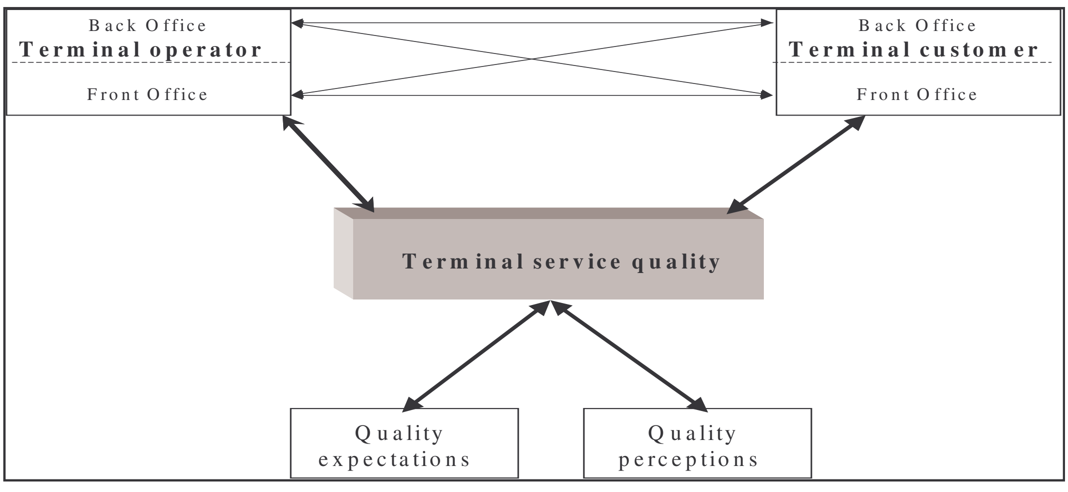

Fig. 4. Terminal service quality environment
Source: Based on de Vries et al., 1994.

Costs of service quality

Achieving quality services costs money. The costs can be made in different parts of the service production process. A useful concept in analysing the cost of terminal service quality may be that of value density (value per unit weight). The value density reflects the relative importance of the container in transit and inventory in the logistics system (Magee et al., 1985). In any business, this suggests that it might be preferable to stock low-value items rather than high-value items. The terminal operator can also use this knowledge: the higher the value of the container the operator is handling, the more important reliability and speed become. Generally, costs of service quality comprise (de Vries et al., 1994):

1 prevention costs (e.g. training programmes);
2 inspection costs (e.g. costs of quality tests);
3 internal repair costs (e.g. costs to repair errors before the service reaches the customer);
4 external repair costs (e.g. costs to repair errors after the service has reached the customer).
5 Lost sales (these do not result in direct costs, but may well represent the highest damage to a company delivering poor service quality.

Delivering good quality services only requires inspection costs and prevention costs, whereas, in the case of poor service quality, costs also consist of internal and external repair costs and lost sales. The total container handling service costs should always be placed in the perspective of the total marketing channel costs. The terminal handling costs depend – as well as on the desired quality level – on container characteristics (value), size of shipment (volume), weight, handling difficulty, density, buying of additional terminal services, and transport distance to and from the terminal. The SERVQUAL-model is used as framework to analyse the terminal service quality.

The SERVQUAL-model

The SERVQUAL-model of Parasuraman, Zeithaml, and Berry (1985) represents a useful instrument to structure the above-mentioned elements of quality research. In this model, the difference between customer expectations and observations (valuations or judgements) is measured. If the expectation of the customer is greater than his observation, there is a lack of quality. Quality is delivered when the observation is equal to the expectation. More quality is delivered if the observation of the customer is greater than his expectation. The expectations must be carefully dealt with, as expectations can be low. In this respect, it is better to focus on the aspirations rather than on expectations. In the terminal interviews, the expectations of terminal operators about terminal customers expectations have been used as a proxy for the important quality elements. The objectives of terminal operators may be stated as cost minimisation/profit maximisation, capacity-oriented and realising political goals (e.g. concerning the environment, enhancement of status and role). Given those mixed approaches towards terminal operations, the importance of terminal quality measurement and improvement is even higher. In particular, the terminal operators may accomplish the increase in terminal service performance and must then define ‘target’ quality levels. The terminal operator should translate the customers' quality requirements into performance statements. The set of quality questions below served as input for the interviews (See Table 1). Knowledge about customer's expectations and observations of the delivered container terminal service quality is the result. Table 1, inspired by Parasuraman et al., gives the terminal operators' overall judgement of quality elements (with 7 being the most important). It has not been possible to interview terminal customers. Testing the SERVQUAL-model with terminal customers is thus an important item for further research. This would make it possible to compare the terminal operators' expectations with terminal customers judgements of service quality.

Table 1: Quality judgements of container terminal operators.

Quality dimension	Questions	Overall importance
Tangibles	1. excellent terminals will have modern-looking (and performing) equipment	5
	2. the physical facilities at excellent terminals will be visually appealing	5
	3. employees of excellent terminals will be neat-appearing (look smart)	5
	4. Materials associated with the service (such as pamphlets or statements) will be visually appealing in an excellent terminal	5
Reliability	5. when excellent terminals promise to do something by a certain time, they will do so	7
	6. when customers have a problem, excellent terminals will show a sincere interest in solving it	7
	7. excellent terminals will perform the service right the first time	7
	8. excellent terminals will provide their services at the time they promise to do so	7
	9. excellent terminals will insist on error-free records	7
Responsiveness	10. employees of excellent terminals will tell customers exactly when services will be performed	6
	11. employees of excellent terminals will give prompt service to customers	7
	12. employees of excellent terminals will always be willing to help customers	7
	13. employees of excellent terminals will never be too busy to respond to customer requests	6
Assurance	14. the behaviour of employees of excellent terminals will instil confidence in customers	6
	15. customers of excellent terminals will feel secure in their transactions	7
	16. employees of excellent terminals will be consistently courteous with customers	6
	17. employees of excellent terminals will have the knowledge to answer customer questions	7
Empathy	18. excellent terminals will give customers individual attention	6
	19. excellent terminals will have operating hours convenient for all their customers	6
	20. excellent terminals will have employees who give customers personal attention	5
	21. excellent terminals will have the customers' best interests at heart	7
	22. the employees of excellent terminals will understand the specific needs of their customers	7

Note: Importance is scored from 1-7.
Source: own research.

The scores in Table 1 correspond with the overall results of the interviews. The results show that most quality aspects are quite important to terminal operators. Reliability, responsiveness, and assurance are particularly important to terminal operators. Tangibles and empathy are relatively less important to the terminal operator. It might be kept in mind that the terminal management has been interviewed that deals with customer's management. If terminal customers' personnel is interviewed, the scores might be different and tangibles and empathy are likely to be more important. In Section 4 and 5, the results will be further analysed according to terminal type.

4. Maritime container terminal service quality

Quality judgement history

In general, container terminal services have no extensive history concerning quality measurement. Some research has been carried out on quality aspects in the field of transport mode comparison and also in the field of logistics. In that field, it has been shown that, in the past, average delivery time was the most important customer service element in correlation with customer satisfaction (see also Table 2). This table indicates the importance of different quality aspects to customers. It not only applies to transport or logistics companies, but also to terminal operators. In the following sections, the results from the terminal interviews will be presented. The maritime service production process will be explored and the measurement of the quality of the services is presented.

Table 2: Contribution of customer service elements of logistics to customer satisfaction.

Customer service elements	Correlation Coefficient (1)
average delivery time	0.76
delivery time availability	0.72
order status information	0.67
rush service	0.59
order methods	0.56
action on complaints	0.56
accuracy in filling orders	0.46
returns policy	0.44
billing procedure	0.39

Note: (1) Correlation between service element and customer satisfaction.
Source: Perreault and Russ, 1976.

Quality and price setting

Some terminal productivity measures may be helpful for the terminal operator to better quantify handling service benefits (improved quality) and costs: firms with high product value have high transport quality demands; large firms with strong bargaining power have a high transport quality; firms located in large clusters have high transport quality; and, the willingness to pay correlates positively with the quality level (Klaesson, 2001). Better quality might thus result in more pricing power for the terminal operator. The benefits for the terminal operator of improved quality management are difficult to quantify, because of the trade-off between costs and quality. This trade-off consists of three variables: service variability; the relative importance of handling costs as compared with total transport costs; and, the nature of the value-added chain (Magee et al., 1985). A broader terminal service package will require significant costs to obtain a high service level. Handling costs versus total transport costs reflects the viability of the different transport options. Finally, the value-added chain decides on the speed with which the different goods need to be handled by the terminal operator. In general, the demand for container transport is inelastic (Coyle, 1994). Thus, container rate reductions (e.g. terminal service charges) will not increase the demand for container transportation dramatically. However, demand is price sensitive on a modal and specific-carrier basis (e.g. combined transport versus single-mode road transport). The interviewed terminal operators indicate that price variability in the continental container terminal market is limited. In the maritime terminal market, handling prices do vary on the port level in Europe (inside ports the competition between terminal operators is less intense). This means that investments in quality in the continental container terminal market, must lead to reduced costs to increase profit levels for container terminal operators.

Maritime service production process

For the maritime container terminal operator, ship services are the most important. All services are offered (ship, yard, and other), but the handling service is of prime importance. The container carriers are the main customers and the central focus is on the quality of service that they receive. The management of the terminal deals with the management of the container carrier, in order to define the desired service levels. At the end of the service chain, the terminal operating personnel and the container carrier operating personnel are present at the terminal handling service delivery. The main characteristics of the maritime container terminal service are presented below. Maritime terminals are open 24 hours a day, 365 days a year. The average transit time for a container is between 48 and 96 hours through a maritime terminal. According to the terminal operators, in the service production process, the reliability of the service is most important for them. Compared with the results from Perrault and Russ (1976), 'average delivery time', 'time availability', and 'rush service', have decreased in importance, while 'reliability' (e.g. accuracy, action on complaints) has increased in importance. See Table 3 for an overview of the main maritime container terminal interview results.

Table 3: Service in the maritime container terminal market.

Variable	Type
Kind of services	Ship, yard, other
Container terminal transit time	48-96 hours
Operating hours	24/7, all year
Critical performance condition	Reliability

Source: Terminal interviews, 2002.

Measurement of maritime handling quality

The maritime container terminal quality importance has been tested on 5 quality dimensions. These dimensions are: tangibles – the appearance of the physical facilities; reliability – the ability to provide the promised service; responsiveness – the willingness to help customers; assurance – the knowledge of the personnel; and, empathy – the caring for terminal customers. The interviewed terminal operators have been asked to divide 100 points between these five items (see Table 4 for an overview).

Table 4. Quality importance in the maritime container terminal market.

Quality indicator	*Share (%)*
Tangibles	20
Reliability	30
Responsiveness	15
Assurance	20
Empathy	15

Source: Terminal interviews, 2002.

The interviews show that 'reliability' is of main importance to maritime terminal operators. The main finding for maritime container terminals is that all quality variables are important, but 'reliability' is the most important one.

Terminal services and quality

Several characteristics of the maritime container terminal service have been tested in the interviews. All promotion channels are used in order to attain and retain customers. Overall, the container terminals are satisfied with their location. The percentage of containers that is not handled according to customer requirements is far less than 1 percent, and the conflicts over false handlings are solved to the maximum extent possible. Maritime container terminal customers expect excellent service, therefore, quality costs are concentrated at the beginning of the internal service production process. Costs are made in order to prevent internal quality defects. Terminal performances measured by the maritime operators are crane performance, container damage, the performance of straddle carriers, and that of other transport modes (besides deep-sea). However, maritime terminal customers are also interested in channel performance, suggesting that terminal operators might start measuring channel performance, in addition to internal performance. The attitude of maritime terminals should change from production-oriented to customer-oriented. A table with the main scores (in the range 1-7) of maritime terminals, concerning the SERVQUAL-model is not given, because the responses on this part of the questionnaire were insufficient. The main result from the limited number of interviews shows that maritime terminals claim that all quality aspects are important.

Conclusion

Several hypotheses have been tested in order to test and fine-tune the main findings in the interviews. The main conclusions for maritime container terminals are presented here:

1 better educated personnel, shorter container terminal transit time, better handling performance, and quality measurement may improve the service handling;

2 reliability is the most important quality criterion for the container terminal.

The most critical performance condition for maritime container terminal operators in terms of quality is thus 'reliability'. Handling speed, information and communication are quoted as important tools to improve the quality performance of maritime container terminals. Reliability of the terminal service should be 'enlarged' to match the reliability of the container handling service in the total perspective of the value chain of the container carriers.

5 Continental container terminal service quality

Quality judgement

In the annual report of RENFE (1998) there is also a short section on quality measurement concerning intermodal freight transport including the use of continental rail container terminals.

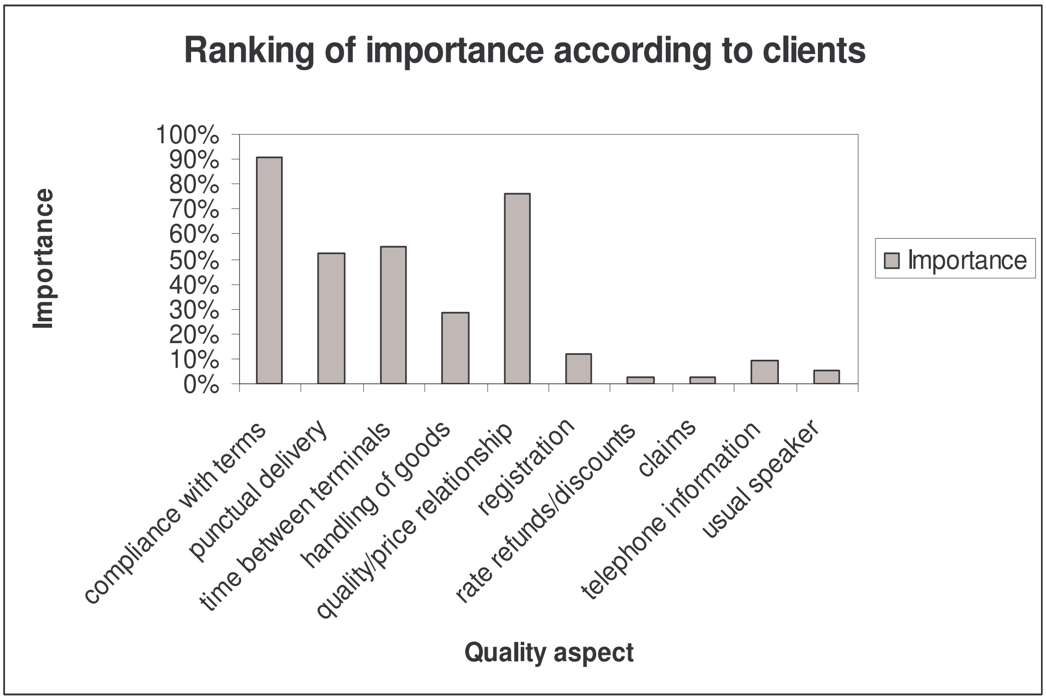

Fig. 5 Quality aspects and customer judgement of rail service.
Note: Usual speaker refers to usual contact person.
Source: Annual report RENFE, 1998.

This quality judgement by customers concerns rail services, including the use of container terminals. It shows that, according to clients, 'compliance with terms' and 'quality/price relationships' are the most important quality aspects. 'Compliance with terms' may also be stated as 'reliability'.

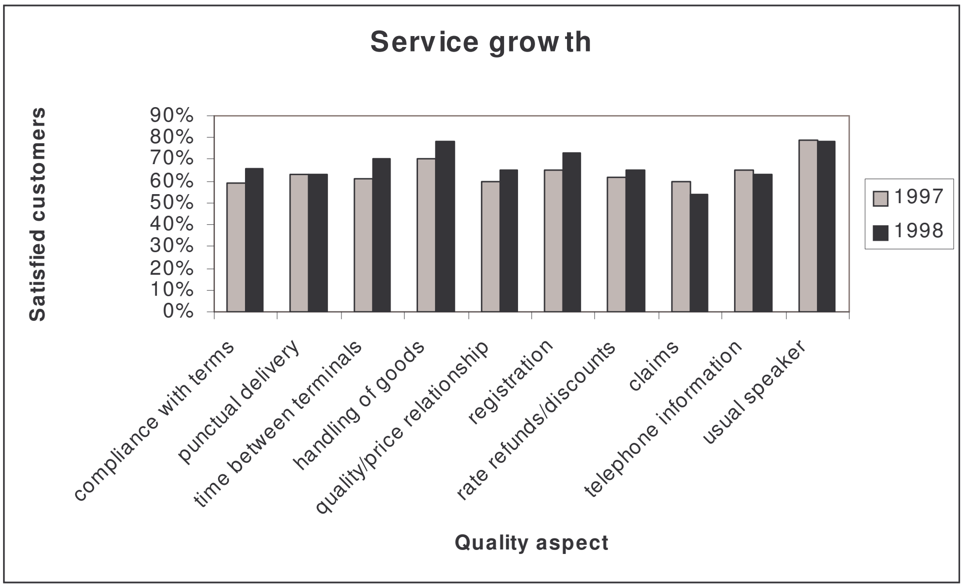

Fig. 6. Development of judgements of quality characteristics of rail service.
Source: Annual report RENFE, 1998.

Figure 6 depicts the development of the quality judgement of RENFE-customers from 1997 to 1998. In general, a well-performing service company may reach levels of 95-99 percent satisfied customers.

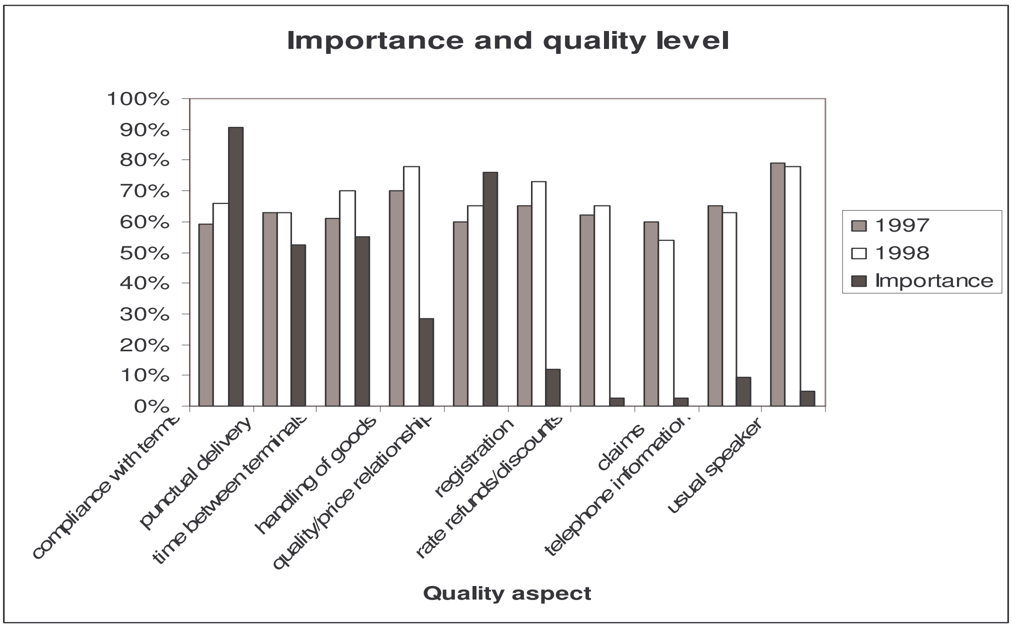

Fig. 7. Importance of quality characteristics and corresponding judgements.
Source: Annual report RENFE, 1998.

Figure 5 shows that the quality aspects that are the most important ('compliance with terms' and 'quality/price relationship') are also those where customers are least satisfied. In general, it is more important for operators to perform better in aspects that are more important to customers. Figures 6 and 7 provide insight into the expectations of and importance expressed by, customers concerning performance and into the actual performance of continental rail services, including terminals, in Spain. This background on the quality performance of RENFE will be related to the results of the interviews in the next sections.

Continental service production process

Most continental terminal operators who have been interviewed have large customer bases, and most of the customers are located close to the terminal. The terminal management deals with the customers' management, in order to define the desired service levels. Ultimately, the terminal operating personnel and the customers' operating personnel are present at the terminal handling service delivery. The distance between terminal management and operating personnel is much smaller for rail and barge terminals, than it is for maritime terminals. The operating hours for barge terminals show a mixed picture, ranging from Monday 05.00 - Saturday 12.00 every week to 24/7, 365 days a year. The average container terminal transit time for barge terminals is 48 hours and for rail terminals 73 hours. In the service production process, reliability of the service is most important (see Table 5 for an overview of the main continental container terminal results).

Table 5. Service in the continental container terminal market.

Variable	Continental barge	Continental rail
Kind of services	Barge, yard, other	Rail, yard, other
Average container terminal transit time	48 hours	73 hours
Operating hours	Most 24/7, all year	Mon. 05.00-Sat. 12.00
Critical performance conditions	Reliability	Reliability

Source: Terminal interviews, 2002.

Measurement of continental handling quality

The continental barge and rail terminal performance has been tested on the 5 quality dimensions mentioned above (see Table 6 for an overview).

Table 6 shows that 'reliability' is of main importance to both barge and rail terminal operators. The main finding for continental barge container terminals is that the differences between the quality variables are not large. This means that all quality variables are important, and 'reliability' must be perfect. Continental rail terminals, on the contrary, are strongly focussed on 'reliability' and less on the other quality aspects. This might be due to the great chance of disruption in the rail transport chain.

Table 6. Quality importance in the continental container terminal market

Variable	Barge	Rail
Tangibles	13	9
Reliability	25	55
Responsiveness	22	13
Assurance	20	12
Empathy	21	11

Source: Terminal interviews, 2002.

Terminal services and quality

Several characteristics of the maritime container terminal service have been tested in the interviews. All promotion channels are used in order to attract and retain customers. Furthermore, the terminal management frequently visits potential and current customers. Overall, the container terminals are satisfied with their location and with the accessibility by barge, road, and rail. The percentage of containers that is not handled according to customer requirements is less than 1 percent for rail terminals, and the conflicts over these false handlings are solved where possible. For barge terminals, the false handlings are between 1 and 3 percent, with one terminal reaching almost 10 percent (interviews with terminal operators, 2002). Barge and rail terminal customers expect ‘reliability’, ‘good price’, and ‘added value’. Terminal performance measured by the barge operators concern barge on-time performance, and customer pre- and end-haulage on-time performance. Rail terminals measure the on-time performance of trains (departures) and trucks (percentage handled within 30 minutes).

Table 7 shows that rail and barge terminals rate the quality dimensions almost equally. All differences are not more than one point. If Tables 6 and 7 are combined, it shows that barge terminals are focussed on ‘offering a total service package’ of good quality. ‘Tangibles’ are relatively less important to barge terminal operators. Rail terminal operators claim that all quality dimensions are important, but if a choice must be made; ‘reliability’ is very important for their overall performance.

Conclusion continental terminals

The main conclusions for continental terminals are:

1 better educated personnel, shorter container terminal transit time, better handling performance, and quality measurement will not enable a price raise per handling. This means that quality improvements must come down into cost reductions. This is even more complicated as the investment costs for improved quality are concentrated at the terminal, while most advantages occur in the networks (Trip and Kreutzberger, 2002);

2 ‘reliability’ is the most important quality criterion for the container terminal;

3 customer satisfaction is influenced by terminal transit time, opening hours, information availability, complaint handling, do what is promised, accuracy, connections, and service quality.

The most critical performance conditions for continental terminal operators are offering a 'total service package' for barge terminals and offering 'reliability' to rail terminal operators.

Table 7. Quality judgements of continental container terminals.

Quality dimension	Barge terminals	Rail terminals	Difference Barge-Rail
1. Tangibles: equipment	5	5	=
2. Tangibles: facilities	5	5	=
3. Tangibles: clothes	5	5	=
4. Tangibles: promotion	4	5	- 1
5. Reliability: promise	7	7	=
6. Reliability: solve	7	7	=
7. Reliability: 1st time	7	7	=
8. Reliability: on-time	7	7	=
9. Reliability: mistakes	7	6	+1
10. Responsiveness: tell	7	6	+1
11. Responsiveness: adequate	7	7	=
12. Responsiveness: always	7	7	=
13. Responsiveness: busy	6	6	=
14. Assurance: behaviour	6	7	-1
15. Assurance: safe	7	6	+1
16. Assurance: careful	6	6	=
17. Assurance: knowledge	7	6	+1
18. Empathy: individual	7	6	+1
19. Empathy: open	5	6	-1
20. Empathy: personal	5	5	=
21. Empathy: customer	7	6	+1
22. Empathy: needs	7	7	=

Note: The quality dimensions on the left-hand side correspond with the extensive described numbers in Table 8.1.
Source: Terminal interviews, 2002.

6. Conclusion

Conclusion for maritime terminals

According to past transport research, average delivery time was judged to be of main importance. The interviews have proven that this has changed for the container terminal sector in Europe. 'Reliability' is now the number 1 quality aspect in their transport services (including container terminal handling). As transport services are, in general, price inelastic, container handling price reductions will not generate a dramatically-increased demand for container handling. The market is very competitive on a port-by-port basis. Quality levels must meet high standards set by the container carriers. Costs, incurred by better quality performance cannot be recovered through higher rates. ‘Reliability’, in terms of meeting container carriers’ demand, is thus a critical performance condition for maritime container terminals. An external performance improvement characteristic might be ‘flexibility’. Deep-sea ship arrivals are no easy planning task, as weather influences and other problematic developments make the terminal operator’s task more difficult. Through strict contracts, all risks of delays and terminal berth congestion are passed onto the terminal operator. This makes ‘flexibility’ a critical performance condition. Measuring ‘total’ container channel performance, through an increased number of terminal performance measures, might help to improve the reliability of container terminals. Most maritime container terminals measure performance on the basis of their terminal; container carriers are interested in channel performance: Is container X reliably transported from point A to B in the agreed timeframe? Internal terminal performance measures must therefore be extended with external terminal performance measures. These external performance measures measure the container carriers’ on-time performance. Critical internal performance improvement characteristics for terminal operators are handling speed, information and communication.

Conclusion for continental terminals

Single-mode transport is the reference point on which the terminal operators base their price. They must ideally meet the single-mode road transport price, or even better, be cheaper. A critical performance condition for continental terminal operators is a ‘total service assortment’. The total service, including pre- and end-haulage (logistics solution) is important, not the container handling only. Secondary services, like container repair or cleaning, further increase sales. The competitive position of continental (mainly barge) terminals is stronger than that of maritime and rail terminals. A large customer base and a broad service package offers opportunities to make money. Another important performance condition for continental container terminals is the ‘small distance’ between the operating personnel and the management. Some terminals measure quality performance, and others do not. It is not possible to recover the extra quality control costs through higher prices. Individualised attention and caring for customers may be as good as making the effort to measure quality performance. Due to the limited scale of continental barge and rail terminals, it is often possible to work without a professional quality performance measurement system. However, if the container terminal grows larger, an automated system to monitor quality performance might be implemented. ‘Reliability’ is a critical performance condition for continental terminal operators, especially for rail terminals, due to the great likelihood of disruption of the system flow, in the rail part of the transport solution. Barge terminals, in order to determine their own quality, but also in order to determine the total channel performance, monitor the start and the end of the trip of a container. The interviews indicated that some barge terminals may be further advanced in measuring transport channel performance than maritime and rail terminals.

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How to boost market introduction of foldable containers? The unexpected role of container lease industry

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Abstract

Transport of empty containers, which arises from the need to reposition containers, is an expensive business. This holds in particular for shipping lines, who are usually responsible for container repositioning and have to bear these container management costs. Shipping lines are known to follow various strategies to reduce these costs of empty transport as much as they can. A rather unfamiliar, but interesting option to save costs is the possibility to fold empty containers. This could save transport costs, but also transhipment and storage costs. Using foldable containers could therefore be commercially attractive, provided that foldable containers can fulfil the technical and logistical conditions demanded by the users. Despite their potential benefits however, there seems to be a reluctance to use these containers.

In this paper we analyse this reluctance and we discuss the important role container lessors could play in initiating the use of foldable containers. The special relationship between shipping lines and container lessors appears to be of particular importance and is a key to pave the way for using foldable containers.

Keywords: Container fleet management; Container design; Container lease industry.

1. Introduction

The arrival of the maritime container in the middle of the 1960s led to a great improvement of freight transport in many respects. The transfer of goods became much easier and safer and the use of containers paved the way for intermodal transport development. At present, the maritime container dominates the shipping industry and the extent of its influence in land transport is also abundantly clear.

An important downside of containerization however is that the place where containers are loaded and unloaded is often not the same, so transport movements of empty containers are unavoidable. These unproductive journeys are not too serious as long as repositioning of empty containers can take place over short distances. However, it becomes a real matter of concern if they result from cyclical or structural imbalances in trade patterns in the world economy, leading to long distance movements.

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On a global level the imbalances in container trades are a familiar and persistent problem. Large amounts of empty containers are being moved around the world. Drewry Shipping Consultants estimate the share of empty containers at sea as 21% of all containers transported. For land transport the estimates are even higher (about 40%). The total costs to the industry of this inefficiency were estimated about 10 billion dollars in 2003. These are the costs of interzonal positioning (i.e. movements including a significant sea voyage). Including intrazonal positioning (i.e. movements overland) would add another 5 billion dollars.

Of course container trade imbalances have always existed, but recent developments have brought the issue to the fore. The demand fallout caused by the Asian financial crisis in 1998 resulted in severe container imbalances on the major East/West trade routes and it took a long time before these imbalances more or less returned to normal. Now imbalances are rapidly increasing again, due to a robust growth of containerised trade within Asia and fuelled mainly by exports from China. Transport volumes coming from Asia largely exceed the volumes going to Asia, resulting in swiftly growing volumes of empty containers bound for Asia (see figure 1). Moreover, based on economic forecasts, it is likely that this pattern will last for quite a time. In view of a strong competition between shipping lines and the role of efficient container fleet management as a key factor in cutting their operating costs the issue of repositioning empty containers is therefore also gaining importance again.

Fig. 1. Container transport volumes in major trade routes (million TEU), 2003

If we review the present strategies of shipping lines to control the costs of empty transport (see Konings and Thijs, 2001), it is interesting to notice that these strategies are mainly focussed on trying to avoid possible transport movements of empty containers, by improving the match of empty containers and cargo. Reliable and up-to-date information about the location of containers and cargo are crucial conditions and sophisticated information and communication systems have proved to be very useful for that. However, all these strategies do not influence the actual costs of empty containers. From this perspective the foldable container could be an interesting addition to the current strategies, particularly knowing that empty transport can never be eliminated completely, even with perfect information systems.

This idea of folding empty containers in order to reduce repositioning costs has been elaborated by Konings and Thijs (2001). The authors have analysed why previous initiatives for foldable containers failed and discussed the technological, economic and logistic requirements for successful commercial applications. In addition Konings (2004) further elaborated the economic aspects in a cost-benefit analysis in which different logistic concepts to use foldable containers have been investigated. The costs and benefits of using foldable containers in different transport chains have been calculated and compared with the situation in which conventional (standard) containers are used. These studies have shown that the use of foldable containers can lead to substantial net benefits in the total chain of container transport, but foldable containers have to cope with scepticism about their technical performance, the complexity of the folding and unfolding process in particular, as well as logistical and organisational problems with using these types of boxes.

However, considering the size of the net (chain) benefits it is striking that this idea of foldable containers is still not picked up. Many designs of foldable containers have been proposed in the past, but only a very few passed through a stage of patent granting, prototyping and testing. The Six-In-One foldable container (figure 2) is one of the rare examples of foldable containers that have been commercially used temporary, but it did not result in a wide application in the market. Here we pose that a major barrier for using foldable containers is risk avoiding behaviour of shipping lines, although shipping lines could gain most from it.

In this article we analyse this reluctant attitude of shipping lines and we discuss the important, but unexpected role container lessors could play, in initiating the use of foldable containers. To understand the potential advantages of foldable containers we start with a brief overview of the general costs and benefits of using these boxes. Next the role of ocean carriers and container lessors with regard to the empty transport issue is discussed and the relationship between these actors is further analysed. It is argued that their relationship offers an opportunity to achieve a breakthrough in the use of foldable containers.

2. Costs and benefits in the use of foldable containers

Evidently foldable containers will only be used if a certain net benefit can be gained. Starting with the costs it is clear that the use of foldable containers leads to some additional costs in the logistic chain. Containers must be folded and unfolded, which implies additional handling (manpower) and usually demands for ancillary equipment.

Another cost increasing factor is the exploitation costs of the container. In general the exploitation costs of a container are mainly determined by its fixed costs, i.e. the purchase price in combination with the depreciation term, and less by its variable costs, such as maintenance and repair, insurance, cleaning, and inspection. The manufacturing costs of a foldable container will be higher than for a standard box[1], because of a more complex construction, so also the exploitation costs will be higher. Moreover, higher maintenance and repair costs will also contribute to higher exploitation costs of a foldable container.

[1] The purchase price of a foldable box can be estimated at around US $ 6.000 (Konings and Thijs, 2001), which is about three times higher as the current price level (2004) of a 20ft standard box (Foxcroft, 2004b).

Possibly there is also a third cost increasing element. It is conceivable that additional transport movements are needed to places where folding and unfolding of containers is

Fig. 2. The folding process of the Six-in-One container
Source: SCC Six-In-One containers company S.A.

facilitated. The occurrence of these latter costs depend on the transport chains in which foldable containers are used. These additional costs should be compensated by cost savings (benefits) somewhere else in the logistic chain in order to make foldable containers an attractive alternative for using standard boxes. The opportunities for cost savings are found in the following activities in the logistic chain:

- *Storage*: if empty containers can be stored in folded state at a terminal or in a depot less space is needed and terminal or depot storage costs per unit can reduce;

- *Transhipment*: if folded empty containers can be bundled and handled together, the terminal transhipment costs per unit can reduce (economies of scale in transhipment);
- *Transport*: if folded empty containers can be bundled and transported together, less transport capacity is needed and transport costs per unit can reduce (economies of scale in transport).

In the study of Konings (2004) these costs have been quantified for different realistic chains, in which the costs of transporting a standard 20ft container and a foldable container have been compared. In summary, it was found that the exploitation costs of a container and the costs of container storage are insignificant, while inland costs generally have a high share in total chain costs. Based on data about a typical transport chain the conclusion could be drawn that the total cost savings in transport (at sea and over land) and transhipment can be substantial. Dependent on the number of links in the chain in which containers are used in folded state the calculated potential savings per container ranged from $ 420 to $ 650 per roundtrip .

The additional costs of using foldable containers should be deducted from these savings to get a net benefit. Since these costs predominantly consist of costs of (un)folding the container (the additional exploitation costs are negligible), substantial net benefits could be gained provided that these costs of (un)folding can be controlled.

3. The position of container carriers and lessors concerning empty transport

In maritime container transport, the shipping company fulfils a central role in the logistic chain. In its capacity as director of transport and container manager the maritime shipping company has a substantial interest in limiting the costs of empty transport. And in its role as transport organiser foldable containers can offer him potential savings in transhipment, storage and transport costs. However, there is a fundamental difference between the potential cost savings in sea and land transport: transport over sea almost always takes place under control of the shipping line. The extent to which folded containers save costs then depends on market circumstances (see Konings, 2004). Market circumstances also play a part in land transport, however, because shipping companies do not carry out this land transport themselves but buy it from providers, there is a direct benefit: the carrier can buy less transport capacity, because transport of empty folded containers saves space.

The container lease company takes up a rather exceptional position in the transport chain: the company's primary role is that of supplier of equipment. It is important for the lease companies to obtain the equipment where there is a demand for it. Attempts are made to bring this about by including agreements in the lease contracts specifying the location where a container has to be returned. However, to be able to respond to local demand for equipment, the lease company has to move containers as well. Therefore the lease companies themselves can also benefit from foldable containers: lower handling costs, lower storage costs for 'off hire' containers in the depot, and lower transport costs for repositioning.

Knowing that the shipping lines are responsible for container fleet management they can be considered as the most interested party for foldable containers of all actors involved in the container transport chain. However, as long as repositioning costs can be passed on to the shippers by imposing imbalance surcharges on the paying cargo or to the container lessors in case of lease containers that can be dropped in low-demand areas, the incentive to capitalise the potential benefits of foldable containers may remain weak. The strategies of shipping lines to limit financial costs and risks in using container equipment can explain this conservative behaviour.

4. A closer look at the relationship between lessors and carriers

Leasing companies have always formed an important part of the container industry, providing spot availability of containers throughout the world. This role is confirmed by the balance of ownership of the world container fleet between shipping lines and leasing companies. During the last decade the share in fleet ownership by container lessors remained fairly stable around 46%, considering that in 1980 container lessors still controlled 54% of global TEU volume (Foxcroft, 2004a). Although there is much to say for owning against leasing containers, it is undoubted that the continuous success of the lessor industry can be attributed to the service they offer of flexibility and the lower daily costs in the short term (Stribley, 2000). Evidently it is beneficial for the shipping lines if they can pick up and drop off containers in response to varying demands of trade, equipment needs and cargo projections. This possibility is particularly relevant for imbalanced trades where load and containers are difficult to match in both directions. In these circumstances lease containers might give the shipping lines opportunities to avoid operating a surplus of containers.

The possible cost advantages of leasing instead of owning can only be explained by the typical financial conditions that characterise the shipping line industry. Stribley (2000) observes that, although the container industry has been very successful in terms of growth, this has not translated into a good profitability for the shipping lines. Containerisation is a capital intensive business and historically, many lines have lacked the balance sheet strength to purchase very many containers themselves. Daily cash flow on leases has historically been lower than bank loans or finance leases and for many lines the focus has been on dealing with the immediacy of cash flow pressures today rather than planning for long term profitability tomorrow. Although Stribley argues that this situation will improve, it will not immediately affect the benefits of leasing containers.

Of course leasing rates are of considerable importance for the trade off between leasing and purchasing, but as a rule the rate levels follow the trends in new build prices. The lease conditions (terms and dropping clauses) might therefore be of greater importance, considering that they are subject to negotiation. To avoid repositioning costs, ocean carriers can gain from careful negotiation of lease contracts, with a pick up in a deficit area, and a drop-off in a region expected to be in surplus when the lease term expires. Although some of these repositioning costs are borne by the leasing company, some of it will also be reflected in the terms of the contract. Depending on contract agreements, ocean carriers may choose to drop off containers at the cost of a penalty fee. Evidence exist that these drop-off charges usually do not reflect the expenses involved in repositioning the container. However, the costs for repositioning borne by the ocean carrier might differ significantly from the lessor, because the latter has to hire container slots from the carrier. Although carriers might try to shift the repositioning costs on to the lessors, it is obvious that such a policy can not be practised on large scale. Ocean carriers are still thrown on the services of lessors. In return, leasing companies are strongly dependent on the carriers being their main client. In this striking relationship however, there seems to be an opening for the introduction of foldable containers into the maritime container transport market.

5. Creating a win-win situation

The reluctance of carriers to invest in foldable containers is understandable, considering the financial burden of purchasing containers. The purchase price of a foldable container can be three to four times the price of a standard box and a substantial number of boxes is required to reveal the system benefits of foldable containers. Apart from this the carrier has to cope with the exploitation risks, which are high because of the innovative character of the foldable container. These barriers could be removed by lease constructions in the way they are applied for standard boxes. Of course, the foldable container has also to fit in the logistic process of the carriers in order to provide a real added value to them (see Konings & Thijs, 2001). In addition to such logistic conditions, the technical and economic conditions are just as much of importance for their acceptance.

Lease constructions will shift the investment risks of foldable containers to the container lessors, but they are not willing to invest in these boxes if the market is sceptic and the sales volumes are highly unpredictable.

A way out of this stalemate for the introduction of foldable containers is via the container lessor industry. Container lessors should not only be willing to offer lease contracts, but should also become involved in operations with foldable containers. The lessor needs to take responsibility for the folding and unfolding of containers. That is to say, the leasing company should organise the assembly and dismounting processes. Containers need to be delivered erected to the shipping line user, so the customer should virtually notice no difference in using a standard box or a foldable container. Of course this assumes excellent technical qualities of the foldable container (see Konings & Thijs, 2001). Once the container has been used and is awaiting a repositioning trip it is handled at a depot, where folded units can be combined into one package, comparable to flat racks. By transporting empty containers in this way savings on repositioning costs will consist of both transport costs and terminal handling and storage costs. Given their strategic locations, existing container depots could be excellent bases to provide these folding and unfolding services. Such activities would be an extension of the current depot services, generating added value, in what is generally considered to be a marginal business sector (see also Wilt, 2004). Due to a worldwide network of leasing company offices these stations to fold and unfold could be in the direct span of control of the lessors.

This approach could bring mutual benefits to carriers and lessors. Shipping lines will gain more flexibility to drop-off containers to overcome cargo imbalance problems or any other causes of a fluctuating demand for equipment. The attractiveness for carriers to drop off containers is enhanced by the possible reduction of drop-off charges, because the lease company can save on repositioning costs. In return, the carriers should be willing to accept a higher lease rate for a foldable container, being the ‘price’ for gaining more flexibility. Although the daily lease rate of a foldable container is estimated as four times higher as the rate of a standard box, these additional costs are very modest compared to the costs of any – unproductive - movement of an empty container.

Container lessors have to bear the additional costs for the folding/unfolding and have to take into account smaller revenues from drop-offs, but substantial savings on the repositioning costs could very well compensate these opportunity costs. Being a neutral operator for different shipping lines means that there is considerable room for economies of scale.

6. Urge for action?

One can debate whether there are sufficient incentives for the container leasing industry to lead the way with foldable containers. It cannot be denied that the lessor industry has been experiencing poor market conditions during the last ten years, although the year 2004 has been a exception (Foxcroft, 2004a). The dramatic decline of new container prices in combination with low interest rates as well as the sharp decrease of utilisation rates, worsened by severe trade imbalances on the major trade routes, caused serious problems for the performance of the industry, both in terms of revenues and profitability. Perhaps it is more debatable whether this was a temporary phenomenon or whether something more fundamental is taking place. The trend towards consolidation in the container industry, the availability of more sophisticated and efficient financing techniques and better ways for shipping lines to manage container trade imbalances worldwide do suggest that ownership of containers by shipping lines will increase in the future at the cost of container leasing business (Stribley, 2000). Without suggesting that the leasing industry will disappear, this is a serious threat for this industry. One of the answers could be that lessors will broaden their services beyond the traditional leasing functions of supplying standard equipment and finance. Of course there are opportunities for greater industry cooperation, including container fleet management, to address the costs of container repositioning, but the foldable container could be an asset to enhance the services of the lessor beyond its present scope.

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The feasibility of mega container vessels

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Abstract

The introduction of the container revolutionised maritime trade and shipping. Since 1956 container vessels have evolved from converted tankers and cargo ships, via full cellular container ships that could navigate the Panama Canal, to post-Panamax vessels with a capacity of approx. 8500 TEU (Twenty foot Equivalent Unit). Even bigger container ships (9600 TEU) are to be delivered soon. However, current technical and physical constraints such as propulsion and port limitations pose restrictions to further growth. Moreover, the diminishing economies of scale in ship costs are offset by the increase of other costs involved (e.g. port fees, terminal handling charges). Nevertheless, empirical research shows that the concept of mega container vessels is appealing and that, if available, most shipping lines will deploy such ships. So, the next generation container ships will probably consist of Suez-max vessels (up to 12,500 TEU) with twin propulsion systems. Albeit feasible from a technical point of view the ultimate 18,000 TEU container ship i.e. Mallaca-max has too many limitations to become popular.

Keywords: Container vessels; Shipping lines; Container revolution.

1. Introduction

With the internationalisation and globalisation of economies shipping has obtained a central role in world trade. Most of the general cargo is transported in containers. The increase in volume of containerised cargo is continuing from the last decades into the beginning of this new century. On most major routes a doubling of volume occurred in less than ten years. The current fleet of container ships with a total capacity of 7 million Twenty foot Equivalent Units (TEU) has also doubled since 1997 (Mainport News, 2004). Moreover, ship size is still increasing. In this paper the (future) development of containerships is examined. From a historical perspective a trend is described towards vessels of 10.000 TEU. Already on the drawing board are Ultra-Large Container Ships (ULCS) up to 12,500 TEU such as Suez-max and even Malacca-max container carriers (18,000 TEU). However, it seems that for these mega container ships new technical and logistical concepts are needed. Via desk research the pros and cons of such vessels were identified. In addition, executives of major container shipping lines in Asia and Europe have been interviewed. Finally, conclusions will be drawn on the feasibility of these mega carriers.

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2. The development of container vessels

2.1 The early years

Modern marine containers are the brainchild of Malcolm McLean, a U.S. truck operator who diversified into shipping in 1955 with the acquisition of Pan Atlantic Steamship Company and Waterman Steamship Company. The dimensions of the first containers were based on the limitations of trailers allowed on the highways at the time in New York State: 35 ft long x 8 ft wide x 8 ft high. McLean converted one of his Pan Atlantic T-2 tankers, Ideal X, into the first vessel that was able to carry containers. By constructing a spar deck over the piping and manifold 58 35-foot container slots, an equivalent of approximately 102 TEU, were created. Using the operating rights of the Pan Atlantic Steamship Company, the Ideal X set sail on April 26, 1956 from Newark (NJ) to Houston (TX), carrying 58 reinforced trailer vans complete with their wheel chassis. Two months later another converted tanker, Maxton, with a capacity of 62 containers (˜109 TEU) joined the Ideal X. These ships came to be known as `Trailerships´.

Already in 1957 the first vessels to solely carry containers stacked in vertical cells, entered service. This series of six converted C-2 cargo ships each with a capacity of 226 reinforced trailer bodies (˜396 TEU), was equipped with two ship-mounted gantry cranes for (un)loading. The first vessel, Gateway City, departed Port Newark on October 4, 1957. In May, 1966 one of its sister ships, Fairland, started the first transatlantic service with full container vessels.

The second shipping line that was heavily involved in early containerisation was Matson Navigation, a major player in the California – Hawaii trade. In contrast with McLean, adoption of the container concept was based on extensive research. On August 31, 1958 the Hawaiian Merchant, one of their C-3 class freighters with a capacity of 70 24-foot containers (˜84 TEU) on deck, sailed from San Francisco to Hawaii with 20 boxes. Again the size of Matson's containers was determined by road regulations; in California the rule on doubling up on trailers was limited to 24 feet for each trailer. In 1960 the Hawaiian Citizen with a capacity for 436 24-foot containers (˜523 TEU), became their first full container carrier. Matson also paid a lot of attention to the transhipment process. In the 1960's port facilities were improved by installing special gantry cranes for rapid and efficient shore-based handling of containers. Soon, it was no longer necessary to put cranes aboard ship. (Muller, 1995). By 1965 these two pioneering container shipping lines handled 70% of US container transport.

The success of the container lies in efficiently facilitating the flow of goods between the transport subsystems of sea, rail, road and, to a lesser extent, inland waterways. The standardised container is a gateway between different subsystems of transportation. Gateway technology is defined by David and Bunn (1988, p.170) as "a means (a device or convention) for effectuating whatever technical connections between distinct production sub-systems are required in order for them to be utilised in conjunction, within a larger integrated production system." However, the introduction of the maritime container in international trade required new standards. In order to achieve operational exchangeability an ISO-committee on container dimensions was installed in 1961. At that moment road regulation in most States permitted 40 foot length and 8 foot width. Since US-regulation was stricter than the dimensions permitted on European roads the proposal of the Americans (then 8 x 8 x 10/20/40 ft) was accepted in 1962.

One year later, these dimensions were supplemented with, among others, lengths of 30 ft. In 1969, the US delegation proposed a height of 8'6", which was used by North Atlantic Services. Although initially accepted exclusively for the 40 ft container, in 1972 this height was also accepted for 20 and 30 ft containers (Egyedi, 2000).

2.2 The Panamax age

Ships built prior to 1969 were converted from break bulk ships or tankers. They generally had capacity in the 750 to 1000 TEU range, draft of about 9 meters, and commercial speeds of 18 to 21 knots and were often fitted with shipboard cranes to handle containers.

In 1968 the first pure cellular containerships was commissioned; United States Lines' American Lancer, was delivered on May 17, 1968. This vessel of 18,764 GRT had a container capacity of 1,342 TEU. Its service speed amounted 17.4 knots. Cellular container ships were designed to utilize dockside rather than shipboard cranes. Removing the cranes both increased cargo-handling productivity and allowed more containers to be stowed on deck. This began a new generation of larger and faster containerships with capacities in the 1,000 to 2000 TEU-range, often referred to as second generation container ships (Cullinane et al., 1997).

European shipping lines followed suit. Already in the early 1970s a further increase in ship size, with capacity moving into the 1500 to 3000 TEU-range, becomes apparent. The maximum capacity of this third generation type of container vessels was limited by the width of the Panama Canal. The first Panamax container ship with the maximum beam of 32.3 meter was Overseas Containers Ltd (OCL) Liverpool Bay of 2,961 TEU, launched in 1972.

At that time service speeds were already important for break-bulk vessels but gained momentum for containerships. Some ships with huge power plant(s) and multiple screws could achieve speeds up to 28 knots. Renowned for their speed were Selandia and Jutlandia of the Danish East India Company equipped with triple screw (!) and three Diesels engines, delivering a 55,250 kW (75,000 BHP). In 1972/73 Sea-Land took delivery of eight 33-knot containerships capable of carrying 1900 TEU. This speed was realized by installing two steam turbines (88,500 kW/120,000 BHP) and two screws. To date, the speed of these SeaLand ships has not been surpassed by subsequent designs. However, they turned out to be an economic failure when fuel prices went skyward and the vessels were sold to the U.S. military. Nowadays service speed is in the 24-26 knot range.

During the second half of the 1980s, the capacity of Panamax containerships rose to more than 4,000 TEU by stretching its length to Panama Canal limits i.e. 294 meter. The famous "Econoships" designed by U.S. Lines to operate on a round-the-world service and delivered in 1984-1985 were able to carry 4458 TEU. In order to maximize fuel efficiency these vessels were equipped with a small power plant but were too slow for the intended service.

The dimensions of the ultimate (fourth generation) Panamax vessel e.g. Hapag Lloyd’s Antwerp Express class, amount 294.2 meter Length Over All, a beam of 32.3 meter (= 13 rows of containers across deck) and a maximum draft of approx. 13.5 meter. This enables a maximum load of around 4,900 TEU, an increase in transport volume of 50 % as against that of the third generation designs. The number of crewmembers at the same time has been reduced by about 40%.

2.3 The post-Panamax era

Post-Panamax containerships first appeared in 1988 when American President Lines ordered five C-10 class ships of 260.8 meter length and 39.4 meter width with a capacity of 4,300 TEU for use in transpacific service. Amazingly, capacity did not exceed the “Econoships”. However, the advantages of such a vessel include lower investment cost i.e. for the same TEU capacity, the shorter post-Panamax ship is 5 percent cheaper to build. Also, the operating expenses are lower because the wider post-Panamax ship requires little or no ballast and thus consumes less fuel. The decision of American President Lines to omit Eastern Seaboards ports from its transpacific service was based on the emergence of double stack container trains. In this way a cost-efficient alternative for the Panama Canal passage was offered

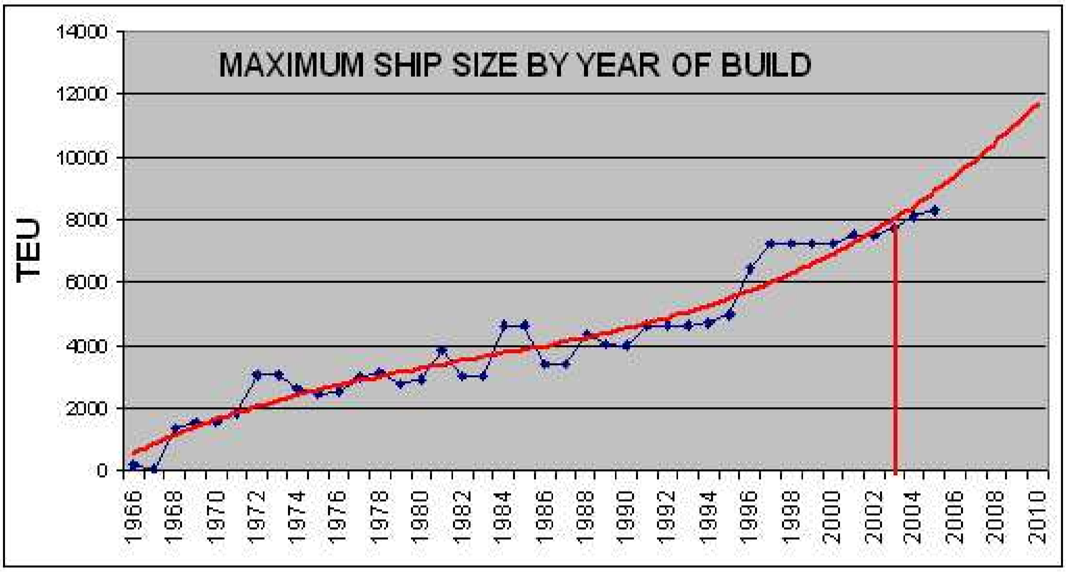
Although the principal advantage of the post-Panamax ship is its virtually unlimited container capacity, the fifth generation type of container ship that was delivered in the early to mid-1990s all had limited LOA’s and beams enabling 15 rows of containers across the hatches. A typical container ship of this generation has a capacity ranging from 5,000 to 5,500 TEU. During this period much attention was paid to the efficiency of the transhipment process and several shipping lines (a.o. Nedlloyd, Norasia) introduced innovative open-top (hatchless) container vessels. Albeit this system was not successful for larger vessels it is still used for smaller containerships including barges.

It took until 1996 when the sixth generation containership was commissioned. The A.P. Möller-group became the frontrunner of these developments. The Regina Maersk, a K-class Very-Large Container Ship (VLCS) of Maersk Line set new standards with a carrying capacity of (more than) 6,000 TEU. The dimensions of the vessel are: Length Over All (LOA) 318.2 meters, a beam of 42.8 meters, spanning 17 containers across the deck, and a draft of 14 meters. Launched in 1998 the Sovereign Maersk, was 29 meters longer than Regina Maersk. The 19 ‘Sovereign’ class vessels are able to carry 6,600 TEUs. Six newbuildings that are even longer (5 meter) than the 347 meter long Sovereign Maersk are (to be) delivered in 2003 and 2004. Its 12-cylinder Diesel engine develops 63,000 kW (equivalent to 85,500 BHP) at 100 revolutions per minute, which allows a cruising speed of 25.5 knots. According to the owner, the capacity of the Axel Mearsk and her sister ships is also 6,600 TEU. Rumouors in the industry, however, suggest a capacity of approximately 10,000 TEU.

The Axel Maersk ranks among the largest container vessels in the world. Officially the 8,000 TEU barrier was breached in 2003 by the 323 meter long OOCL Shenzhen with a capacity of 8,063 TEU. At the time of ordering the engine restricted capacity to 7,700 TEU but due to technical innovations it could be increased. At the moment the largest containership in the world is China Shipping Container Line’s (CSCL) 8,486 TEU ASIA. Additionally, four sister ships will be joining CSCL’s fleet. The dimensions of these vessels: Length Over All 334 meter, beam 42.8 meter and draft 14.5 meter. The air draft of such a vessel is 61.5 meter! A twelve cylinder 68,615 kW (93,120 BHP) Diesel engine with 104 rpm provides a service speed of 25.2 knots. The container vessel took a total of 16 months to complete, 8 months in designing and another 8 months in construction. (Samsung Heavy Industries, press release 2004/07/07)

2.4 Future trends

The graph below shows the actual increase of container ship size until the year 2000. Existing information about newbuildings is also included but already outdated by recent developments. By extrapolating the data a trend is derived.



Source: Lloyd's Register and Ocean Shipping Consultants Ltd, 2000.

Since the mid-1990 the size of container ships has increased rapidly and newbuildings keep getting bigger. As of 1st January 2004 already 30 container ships of above 7,500 TEU are in service and another 126 ships are on order (http://www.brs-paris.com/). Up to around 10,000 TEU vessels will reflect current design parameters and will be powered by a single main Diesel engine, with a power output of 66,500 kW (90,000 BHP) plus, generating a minimum 25-knot service speed. Compared to the design of the CSCL Asia it will take about a year to design such a vessel. Anything beyond that size will have to be twin-engined, particularly, if a 25-knot service speed is to be maintained. For these vessels the Suez Canal imposes the next boundary. The slightly V-shaped bottom of the canal allows common U-hulled Ultra Large Container Ships (ULCV) of 400 meter length, beam of 50 meters (= 20 containers) and draft of 17 meters. Such a Suez-max vessel can carry up to approximately 12,500 TEUs. From a theoretical point of view the size of containerships is constrained by the maximum depth for transiting the Mallaca Straits. This vessel, called Malacca-max, is 400+ meters long, 60 meters wide (= 24 containers) and has a draft of 21 meters. It would be able to carry roughly 18,000 TEUs. (Wijnolst et al, 1999).

3. Barriers to further growth

The development of ever-larger container ships is, however, restricted by technical and physical constraints, logistical implications and economic aspects.

3.1 Technical and-physical constraints

Propulsion

As mentioned before, the currently available Diesel engines do not allow substantial increases in ship size anymore. The largest slow-speed Diesel engines provide propulsive power for a post-Panamax ship of about 8,500 TEU to achieve a service speed of about 25 knots, the industry standard. Beyond this size, larger or two engines have to be installed. It is clear that shipowners prefer the well-proven concept of one engine, one propeller. Recently, two designers and licensors for large slow speed Diesel engines have developed stronger engines. Single screw containerships of 10,000 TEU+ are feasible with these engines. However, the overall length of these engines may cause problems with engine rigidity as well as regarding possible interaction with the hull, an aspect requiring careful examination, particularly in view of its effects on the engine. Moreover, the propeller is coming close to its limits.

The above-mentioned limitations will make a twin propulsion system a viable alternative. Twin-propulsion systems have several advantages such as redundancy and more flexibility regarding partial load. This is important when a port comes in sight. For a design speed of 25 knots, two of the largest twelve cylinder engines installed leads to a mega container vessel of about 15,000 TEU. With even larger engines, the 18,000 TEU Malacca-max container ship will also become feasible. However, twin propulsion systems are significantly more expensive and will require more maintenance effort in operation. (Payer, 2002)

Port limitations

Of great importance for mega vessels are the harbour waters, berths and approach channels, there must be sufficient depth to accommodate the large vessels. A 16.5 meter deep port entrance allows access, albeit sometimes with minimal under-keel clearance, to nearly all containership now in existence. However, mega container carriers need up to 22 meters deep entrance channels. Currently, only a few ports are able to accommodate mega vessels. In the Far East and Europe the draft problem is less imperative than for (East Coast) U.S. ports where the question of how to achieve sufficient water depth is a vexing one.

An aspect often forgotten in the discussion is the problem of ‘air draft’ i.e. the distance between the water surface and the highest point of the ship. At the moment very large containerships such as CSCL’s Asia have an air draft of 61.5 meter, which is close to the clearance of some bridges spanning the port entrance. The Bayonne Bridge in New York is a good example in this respect.

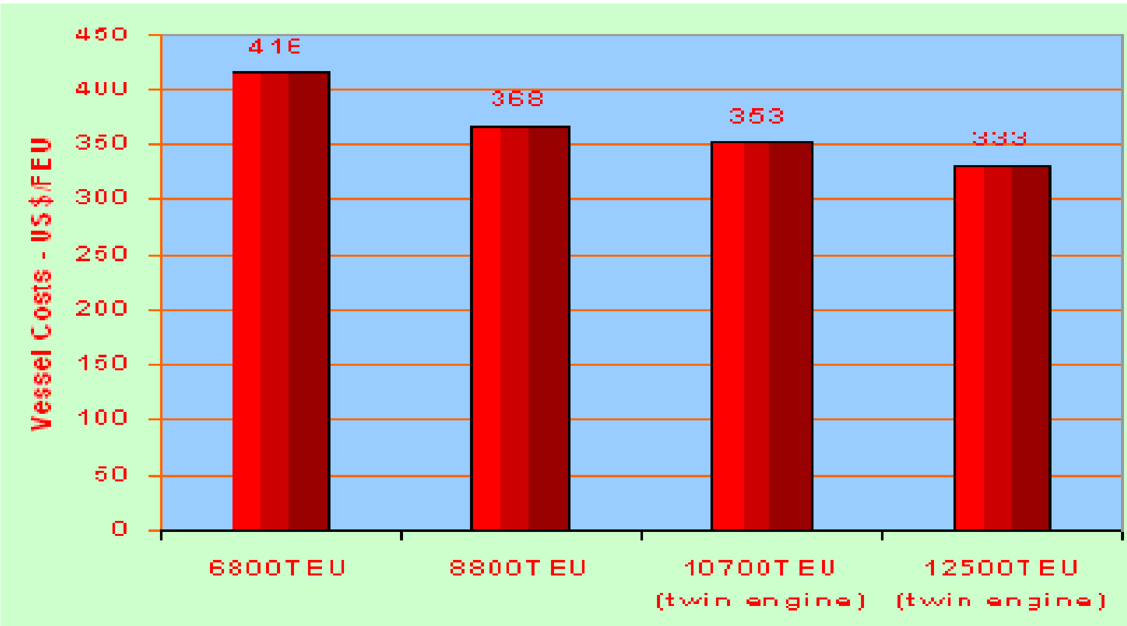
3.2 Logistical implications

Transhipment

Current post-Panamax vessels carry a maximum of 17 rows of containers across deck. Therefore, container cranes must be capable of spanning 17 rows of containers stacked 7 tiers high on deck. The practical limit for a ship of more than 300 m in length is about 5 to 6 gantry cranes simultaneously with a maximum performance of 120 to 150 moves per hour per ship. Albeit 9,000 TEU containerships can be handled by a crane capable of spanning 18 rows stacked 16 to 17 high, new ideas and concepts are needed here to keep pace with the developments of the large container vessels. Further improvement of productivity, can be achieved by increased speed for the crane movements, double trolley cranes and servicing the biggest ships from both sides in a berth. In 2001, such a terminal was constucted in the port of Amsterdam: the Ceres Paragon Terminal.

3.3 Economic aspects

A prerequisite for the introduction of larger container ships is their economic viability compared to today's fleet. This was examined in depth by Ocean Shipping Consultants (OSC, 2000). The clear conclusion was that the trend is upwards to 12,500 TEU capacity. At that point infrastructure limitations constrain the operational flexibility of the vessels. The chart indicates the scale economies per 40-foot container (= 2 TEU), taking into account the major costs associated with trading the vessels, including capital charges, maintenance, crew and fuel. The calculations have been carried out on the assumption that a service speed of 25 knots will be required across this entire range of ship sizes. This necessitates a twin-engine installation for ships of 10,000 TEU and above.



Source: OSC (2000)

Not everybody agrees with the above-mentioned economies of scale in ship costs. Stopford (2002), one of the main critics, opposes the idea of a substantial decrease in cost per container. He states that beyond 5,000 TEU, economies of scale diminish very rapidly. The three key elements in the economies of scale calculation encompass capital costs, operating expenses, and bunker costs.

- Capital costs:

Investors do not save very much capital by building super ships. The cost of the ship increases from $12 million for a 725 TEU ship to $64 million for a 6,000 TEU ship but beyond that there is little further reduction per TEU. So the capital saving per 1000 TEU is quite small. For mega ships the same principle seems to apply. At an anticipated cost of $181.5 million an 18,000 TEU ship costs only $ 10 million (5%) less than three 6,000 TEU vessels.

- Operating costs:

Operating costs, which include crew, insurance, stores, maintenance and administration, also offer less opportunity for economies of scale than appears at first sight. Administration, stores and manning do not increase significantly, so there are scale economies here. However insurance and maintenance costs are likely to increase in line with the capital cost of the ship, offering little scale economy.

- Bunkers:

Finally there is fuel consumption. Regression analysis suggests that increasing a ship's capacity by 1,000 TEU raises the bunker consumption by 31.8 tonnes per day (though a more thorough analysis would take account of the faster speed of bigger ships). So there are almost no economies of scale in bunker consumption, at least over such a wide TEU range.

Moreover, maximising ship size neglects the other costs in the transport chain. Ship related costs only account for less than a quarter of the total door to door delivery cost. The components of these costs consist of:

1. The ship (23%); the share of the above mentioned costs diminishes for bigger ships.
2. The containers; including maintenance (18%); this cost is not directly influenced by ship size but there might be congestion driven diseconomies.
3. Ports and terminals (21%); the port sector certainly faces significant diseconomies of scale due to the cost of dredging as draft is deepened. However, these costs can often be allocated to port authorities since they are eager to accommodate large containerships. In contrast, terminal cost will be fully incurred on shipping lines, especially since they are more and more involved in terminal operations.
4. Inland transport (25%); these costs are not directly related to the size of ship, but there are logistics issues which do not necessarily favor big ships. Generally speaking, a transportation asset such as a ship must be in motion to assure its economic survival. So, liner shipping companies need to minimise port time and mega container carriers will only call at a few hub ports. Some scenarios suggest that 15,000 TEU (or larger) container ships are deployed on the main East-West routes. North-South linkages are maintained with feeder ships from 250 to 6,000 TEU. The most likely locations for the four "mega hubs" in the world are Southeast Asia, the Western exit of the Mediterranean, the Caribbean and the West Coast of Central America. So the region served by a hub port will expand and the cost of inland transport will increase.
5. Other costs, including container repositioning (13%); not ship size related, except possibly some small saving in administration.

4. Empirical research

The introduction of mega carriers of 12,500 to 18,000 TEU-range depends on decisions made by container shipping lines. Their policy regarding the deployment of vessels, hub and spoke networks and ports of call will determine the future of mega carriers. So, what is their idea about the developments in the container sector? Will they use mega container vessels in the future? In order to obtain answers on these questions executives of major container shipping companies, including the top 5 operators, were interviewed. Since Very Large Container Vessels are the workhorses of the Asia-US and Asia-Europe route, shipping lines in Antwerp (MSC), Hong Kong (Hapag Lloyd, MSC, P&O Nedlloyd), Koahsung/Keelung (APL, Evergreen, Yang Ming) and Rotterdam (Evergreen, Maersk Sealand) were interviewed during the first half of 2003. The results are summarised in table 1.

			MEGA CONTAINER VESSEL (12.000 – 18.000 TEU)				
	Fleet (rank)	Biggest vessel (in TEU)	Feasibility		Anticipated problems		
Name					Vessel	Port/terminal	Operation s
Maersk Sealand	*1*	*6.600 (or more)*	*yes*	*long term*	*engine*	*berth length handling capacity cranes (terminals are crucial)*	*hub-and-spoke inland hubs*
Mediterranean Shipping Company (MSC)	*2*	*6,750*	*yes*	*long term*		*waiting time*	*new calling pattern*
Evergreen	*3*	*6,332*	*no*		*draft*	*gantry cranes*	
P&O Nedlloyd	*4*	*6,802*	*yes (technical) no (economical)*	*long term*	*engine draft.*	*terminal facilities, hinterland connections, waiting time*	*calling pattern (more feedering)*
CMA(Compagnie Général Dáffrètement) - CGM (Compagnie Général Maritimes)/	*5*	*8,238*	*yes*	*long term*		*supra- and infrastructure*	*hub-and-spoke*
Orient Overseas Container Line (OOCL)	*14*	*8,063*	*yes*	*medium term*	*engine*	*dedicated terminals*	*mature markets*
Hapag Lloyd	*16*	*7,506*	*yes*	*long term*	*draft*	*gantry cranes*	*hinterland connectio ns more containers*

In general, shipping line companies consider mega container carriers feasible from a technical point of view, albeit not in the near future. From an economical point of view feasibility is less apparent. Most shipping lines need to adapt their hub-and-spoke network substantially and therefore reduce the number of ports of call or serve only mature markets. Feedering by smaller vessels and inland transportation will become more important. P&O Nedlloyd considers such type of operation economically not viable. If mega container carriers are introduced huge investments in ports and terminals are needed. Since shipping lines increasingly operate their own terminals, they have to pay for new gantry cranes with an outreach of 24 containers themselves.

5. Conclusions

Undoubtedly, the trend of increasing ship size has not yet come to an end. Growing (Asian) markets require container capacity and shipping lines will provide it. Technically speaking mega carriers are feasible but from an economic point of view the benefits are small. Momentarily traditional concepts are stretched to its limits. Obviously, the new generation container ships are twin screw with two engines. If this is a success the next frontier is the Suez-max vessel up to approx. 12,500 TEU. The ultimate container vessel, the Mallaca-max probably has too many limitations to become a new standard.

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The shipper's perspective on distance and time and the operator (intermodal goods transport) response

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Abstract

This paper is about distance and time in alternative bundling networks and roundtrip models. First the relevance of transport costs and time for customers of intermodal transport is reviewed. Then the paper focuses on vehicle roundtrip design in European intermodal rail networks and the perspectives to accelerate roundtrip speed. Acceleration often implies an increase of service frequency. As transport volumes often will not justify higher frequencies, the introduction of so-called complex bundling (e.g. hub-and-spoke or line services) may be an outcome. Complex bundling allows applying a relative large vehicle scale, despite of restricted flow sizes. This cost advantage is likely to overrule the cost disadvantage of longer routes in complex bundling networks. An important indication for this fact is a comparison of total network distances and times. The last part of the paper compares the distances and times of about 150 networks (different bundling concepts and network geometries). It shows that the additional length of routes of complex bundling networks is always overruled by the distance and time impact of a lower number of connections between begin- and end terminals in complex bundling networks

Keywords: Intermodal goods; Time; Distance; Networks; Bundling; Roundtrips.

1. Introduction

Distance and time are key factors in the design of transport and logistic networks as they indirectly influence the costs of vehicles, load units and goods in circulation, and node infrastructure.

Public and private transport companies are generally interested in cutting transport times by, for example, reducing distances. This could be achieved by choosing routes in an infrastructure or service network that minimize distance, by adding missing infrastructure or service links and, last not least, by increasing driving speeds on links and/or reducing node times (thereby reducing link times).

Section 3 of this paper deals with a part of this spectrum, namely, the acceleration of transport. Section 4 concentrates on the relevance of distance and time in complex bundling networks. This subject has scarcely been researched, even though bundling

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choices affect distance and time through more channels than simply the network layout (choice of route determined by infrastructure or service/vehicle). It is therefore no coincidence that roundtrip and innovative bundling are the main strategies for making intermodal transport more competitive.

The themes of Sections 3 and 4 may appear separate at first glance but are actually closely interrelated.

The paper starts (Section 2) with a brief literature review on the import of the cost and quality of transport for shippers. Section 5 presents the summary and conclusions.

2. What transport time means to the customer

Unimodal road transport is the reference point for intermodal transport. Whenever shippers or other purchasers of transport services choose a modality, route or company, they pay attention to general costs, door-to-door (DTD) costs, frequency, reliability (in terms of time, damage and loss), flexibility, maximum weight and size of the shipment, the possibility of sending partial loads (LCL-/LTL), and the quality of information (e.g. the status and position of freight). Some customers may also be interested in secondary performances[1].

People are becoming increasingly aware of the relevance of these factors in the choice of modality. Almost all the consulted studies conclude that the price/cost[2] of goods transport is the most important factor in the overall performance. CONFETERA (1997) elaborates on this a little by indicating that reliability is slightly more important in the material management phase than in the distribution phase[3] . The transport price consists of time, distance[4] and other elements (e.g. profit, taxes). IQ (2000)[5] observes that a good price matters most to users of intermodal transport. For users of road transport it is quality that matters most.

The studies are less specific on the question of which factor is most important after costs: reliability, DTD time, frequency… – all of which create extra costs for the customer, such as interest charges for goods in circulation, and buffer costs, which are not already incorporated in the transport price.

Time reliability is most important, coming ahead of transport time, according to SPIN[6] (2002), IQ (2000), CONFETRA (1997), Beuthe et al. (2003)[7] and Vandaele and Witlox (2003)[8]. The seven cases cited by Bergentino et al. (2003) [9] are characterized by

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[1] Examples: the synchronization of sequential transport services, the possibility of buffering loaded or empty units for a while, the quality of road accessibility at terminals, or the number of destination regions which a train or barge can access from a specific start terminal without increasing the pre- and post-haulage distance too much.

[2] The transport prices are costs to the customer.

[3] By 0.1 point on a scale of 1-5.

[4] The time costs are often regarded as fixed and the distance costs as variable. De Jong *et al.* (2004) apply an alternative distinction: depreciation represents fixed costs (as above), and labour represents variable costs (contrary to above).

[5] IQ = Intermodal Quality. This European study raises the question of the key performances which make a customer choose intermodal or unimodal road transport.

[6] SPIN = Scanning the Potential for Intermodal Transport.

[7] They analyse the preferences of shippers in different industrial sectors. Indicative results are presented for 6 sectors. Some make use of road, some of barge and others of multimodal transport.

[8] They analyse the preferences of shippers in different industrial sectors. Indicative results are presented for 5 sectors. Some use road, some use barge and others use multimodal transport.

relatively low frequencies. The seven companies therefore regard frequency as far more important than transport time or reliability. For road transport De Jong et al. (2004) estimate a higher trade-off for[10] a 10% increase in transport time than for a 10% decline in reliability. This result also applies to a subpopulation in the research, namely, the unimodal road transport of containers.

Some studies conclude that transport time, despite its impact on transport costs, is not important at all: SPIN (2002, page 21) states that "once taken and agreed the transit time offered by intermodal services, generally longer than road transport, has less relevance for shippers than other 'criteria'". LOGIQ (1998[11]) draws the following conclusion: "Intermodal transport … is not chosen … by companies requiring shorter lead times". In this framework De Jong et al. (2004, page 25) distinguish between shippers with their own transport and shippers with outsourced transport.

As already indicated, according to IQ (2000), users of road transport consider quality more important than price. The highest score goes to flexibility, followed by 'a good match with the logistic structure', and then followed at some distance by reliability. In intermodal transport the match with logistic structure is the most important factor, again followed at some distance by reliability. Time is the third most important factor. Beuthe et al. (2003) and Vandaele and Witlox (2003) present new techniques for analysing stated preferences, especially with regard to intermodal performance indicators and choice of modality. They draw the preliminary conclusion that DTD times, including (un)loading, account for 0%-36% or 0%-23%, depending on the sector. This is not always less than the importance accorded to reliability[12]. The high values relate to electronics and textile and the low values to chemicals, cement, packaging or plastic and steel.

The importance of time depends partly on its definition. For example, Weinreich et al. (2000) see waiting times due to (a lack of) synchronization of sequential vehicles in a chain[13] as a characteristic of 'flexibility'. Other researchers do not analyse waiting times at all. This is one respect in which the importance of time is likely to be underestimated.

On the other hand, answers to the question about the intrinsic value of time suggest that it is often overestimated. It is based on the following considerations:

- Interest charges arising from goods in circulation (= part of the storage costs). All consulted sources mentioned this component;
- According to some studies, loss of value (Weinreich et al., 2000; RECORDIT[14], D1; Daganzo, 1999) and spoilage costs (Weinreich et al., 2000) also play a role. It seems to me that, unless we are dealing with a long-term fundamental upward or downward economic trend, loss of value will eventually be compensated by gain of value. This component therefore does not appear plausible.

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[9] They interviewed seven companies, most of which are forwarders, who do not carry out physical transport. Six companies use road transport, one uses maritime roro services.

[10] The response to the questionnaire is too small to make comparable statements for other modalities.

[11] According to SPIN, 2002, p. 45.

[12] The weights of reliability are – for comparison – 0%-36% or 0-31%.

[13] For example, the synchronization of rail transport and pre- and post-haulage with the production rhythm of shippers. The night jump of trains is an example of synchronization, which is favourable for shippers who adhere to the 8-hour economy.

[14] RECORDIT investigates the external costs for three freight corridors. For each corridor an intermodal transport chain and its reference, unimodal transport, is analysed. The importance of time plays a role in the framework of congestion costs.

Spoilage does not happen under normal circumstances and should therefore be incorporated in 'reliability' rather than in 'time'.
- 'Opportunity costs' of the involved capital (Daganzo, 1999, P. 23). The shipper could have invested in other areas. Or the shipper has missed the chance to invest in more efficient distribution systems (De Jong, 2004).

Though the interest charges that shippers pay for goods in circulation capture the imagination, they are very small, ranging between 0.3 and 1.6 euros per hour and load unit (an interest rate of 6% for goods with a maximum value of 160,000 euros per load unit). Freight travelling from a Benelux harbour to a terminal in North Italy would generate DTD interest charges of 10-65 euros per load unit. The DTD transport costs are in the region of 700 euros per load unit. Hence, the time costs of goods in circulation are lower than 1-10%.

One rather important feature with regard to the time and reliability indicators is the conflation of shippers with other players in preference analyses, as is the case in De Jong et al. (2004). In this study uniform trade-offs are calculated for shippers/consignees and transporters, while – conceptually – these two groups understand the importance of time and reliability in fundamentally different ways.

These and other methodological differences between the studies explain the rather large range for the value of time. The following overviews are provided by Weinreich et al. (2000), Tavasszy et al. (2002) and De Jong et al. (2004).

Weinreich:
- 2 euros per hour and load (approx. 39 tons, value approx. 55,000 euros; Oregon, 2000). This valuation takes only interest charges into account;
- 0.3-1.2 euros per hour and ton for road transport according to PETS (Christensen et al., 1998), depending on the type of goods (e.g. short-cycle products or seasonal bulk).

Tavasszy (literature review):
- only road transport:
- 0-60 euros (2002) per hour and load (truck), excluding a few extreme values;
- 0.08-1.53 euros (2002) per hour and ton.
- rail transport: 0.03-1.21 euros (2002) per hour and ton;
- water transport: >0.05 – 0.09 euros (2002) per hour and ton (plus one very high value).

The actualization of time valuation by De Jong for the Netherlands leads to (road) 36-49 euros (2002) per hour and load, or (for large trucks) 2.12-3.25 euros (2002) per hour and ton, depending on the market segment. The high edge is for containers by road.

Beuthe et al. (2003) give a preliminary indication of the benefits of one day less transport time in the steel industry, namely 0.07 euros per ton (or 0.06 euros per hour and load unit[15]). One additional day is accepted at two euros per ton (or 1.8 euros per hour and load unit).

Bergentino et al. (2003) conclude, that in the cases they studied, the reduction in transport time is equivalent to 0.64 euros per hour and ton (range: –0.73 and +1.59). This is equivalent to about 14 euros per hour and load unit.

Summarizing, the impression is that studies which focus exclusively on shippers and intermodal transport deliver two alternative levels of value: one at □2 euros per hour and load unit (= low edge, based mainly on interest costs), the other at □2 euros per

[15] = * 22tons/24 hours.

hour and ton (= high edge). Bergentino's average value is exceptionally high. Other studies also contain much higher values.

Apparently, the last word on the importance of time – irrespective of the importance of time in transport costs – is still to be said. One could argue, that even if intermodal customers did not assign a high value to time, the fact that road customers consider it important should be enough reason to work hard on reducing transport time in intermodal networks. This is also the conclusion of various innovation platforms (e.g. the German KV Technology Platform 2000+, 1995, or ECMT, 1998). They maintain that if intermodal rail transport is to become more competitive, it needs to resemble road transport more and therefore should achieve higher system speeds[16] etc.

Incidentally, shippers do make quite illustrative statements on the importance of time; like Volvo, who stated that a one-day reduction in journey time would save the company US$ 20 per car (World Cargo News, 1995). This is not much compared with the value of a car, but it still prompted Volvo to initiate innovative short-term sea-shipping concepts. Some of the savings would be invested in more advanced means of transport, which would help to save time.

A look at the logistic costs of companies in Europe also challenges one to draw the 'right' conclusions. Depending on the sector, transport costs work out at about 2.2% - 4.7% of the sales value. These costs are part of the logistic costs, which represent 8.8% - 13.4% (European Logistics Association and A.T. Kearney, 1993). Time reduction – in relation to transport costs – only reduces a part of these ranges.

There are moments when the importance of time manifests itself so strongly that the discussion spills over into more practical domains. Take, for example, the design of train roundtrips. Is it better to allow a train to wait a long time at a **BE terminal**[17] until a departure moment turns up which is favourable for shippers? Waiting costs time and pushes up the rail costs. But the synchronization matches the rhythm of a shipper working in an 8-hour economy. These shippers prefer trains to depart in the evening and arrive late at night or early in the morning.

The opposite model is one in which the train returns to the links as soon as possible after terminal handling, taking account, of course, of periodicity requirements (see below). The time then spent at the terminal (ideally) consists only of the time for primary and secondary handling plus minimum periodicity time and buffer time to compensate for unreliability on links and at nodes. The roundtrip takes less time, so the rail costs are lower. But the DTD time of the load unit will not necessarily be reduced as well. On the contrary, the waiting times of a load unit at the terminal or the shipper's premises may then increase, bringing higher buffer costs (buffer costs are related to compensation for lack of synchronization).

If a short time spent at a terminal means that the train departs and arrives at unfavourable times for the customer, then the train operator should compensate by lowering the prices. This compensation should be covered by (a part of) the time-cost savings of trains.

[16] Next, the rail product should be made suitable for shorter distances and partial loads.
[17] A ***BE terminal*** is a begin-and-end terminal. These are located at the ends of a rail connection.

3. Roundtrip times of trains and door-to-door times of load units

The departure and arrival times of trains ought to be periodic to make them recognizable to customers. In other words, vehicles would arrive and depart at a BE terminal at the same time of day. As a result, trains would stand still for quite some time. The standstill time would depend on the distances and the average link speed.

Figure 1 shows alternative roundtrip models for distances of 300 km, 600 km, 900 km, 1200 km and 2100 km[18].

The roundtrip stake:

- (300 km) 12 or 24 hours. The time at a BE terminal D is 4 or 16 hours respectively per roundtrip;
- (600 km) 24, 36 or 48 hours. The time at a BE terminal is 8, 20 or 32 hours respectively per roundtrip;
- (900 km) 36 or 48 hours. The time at a BE terminal is 14 or 26 hours respectively per roundtrip;
- (1200 km) 48 hours. The time at a BE terminal is 18 hours per roundtrip;
- (2100 km) 72 or 96 hours. The time at a BE terminal is 20 or 44 hours respectively per roundtrip.

These roundtrips apply to the wagons of a train. If the wagons at a BE terminal have a long node time, the locomotive is ideally assigned elsewhere: it will be linked to another set of wagons, which have already been handled at the terminal, and pull them through the network, leaving its 'own' wagons behind for handling. However, in practice – and certainly in the case of new operators – the locomotive is more likely to wait for its 'own' wagons[19], even though locomotive costs weigh heavily, as the following example illustrates. For a distance of 600 km the night jump takes 48 hours (Figure 1). The roundtrip could also be realized in 24 hours. This would reduce costs by 70 euros per load unit[20]. The total rail costs then change from 340 to 280 euros per load unit[21].

As already indicated, roundtrips which are a multiple of 48 hours have night jump times and hence customer-friendly arrival and departure times for all trains: Outbound and homebound in all roundtrips. The proportion of time spent at BE terminals is between 33% and 67%. Take, for instance, the distance of 600 km with a night jump connection: in this case the train spends 2/3 of its roundtrip at BE terminals. The time at a BE terminal can often be reduced[22], but then one needs to look at the impact of periodicity and frequency. Some reductions immediately result in a new periodicity (e.g. 48 hours is reduced to 24 hours for a distance 600 km). Other reductions require an additional service to recover the diminished periodicity, because the reduced roundtrip times imply more than one departure time a day. An additional service needs to be

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[18] The arrows (1st = outbound, 2nd= homebound) have been set on the time axis in a way which makes the roundtrips easy to compare. Therefore, each roundtrip starts at 0 o'clock. In reality customer-friendly times are applied if possible: the train departs as late as possible in the evening and arrives as early in the morning as possible. In this sense the outbound arrows for distances up to 900 km (possibly even 1200 km) lie symmetrically around 0 o'clock.

[19] The operational design for different roundtrip times for wagons and locomotives is more complicated than a design for the same times. In addition, the size of the network volumes and the train operator can prohibit the acceleration of the locomotive roundtrip.

[20] A load unit in this paper is defined as a 1:1 mix of 20' and 40'cotainers, or of corresponding swap body sizes.

[21] In accordance with the RACOM rail cost model (Kreutzberger, 2003).

[22] The minimum time is the sum of time for handling and to compensate for unreliability.

inserted to guarantee the same departure times on departure days. Such an increase in frequency can, however, only take place if there is sufficient freight volume.

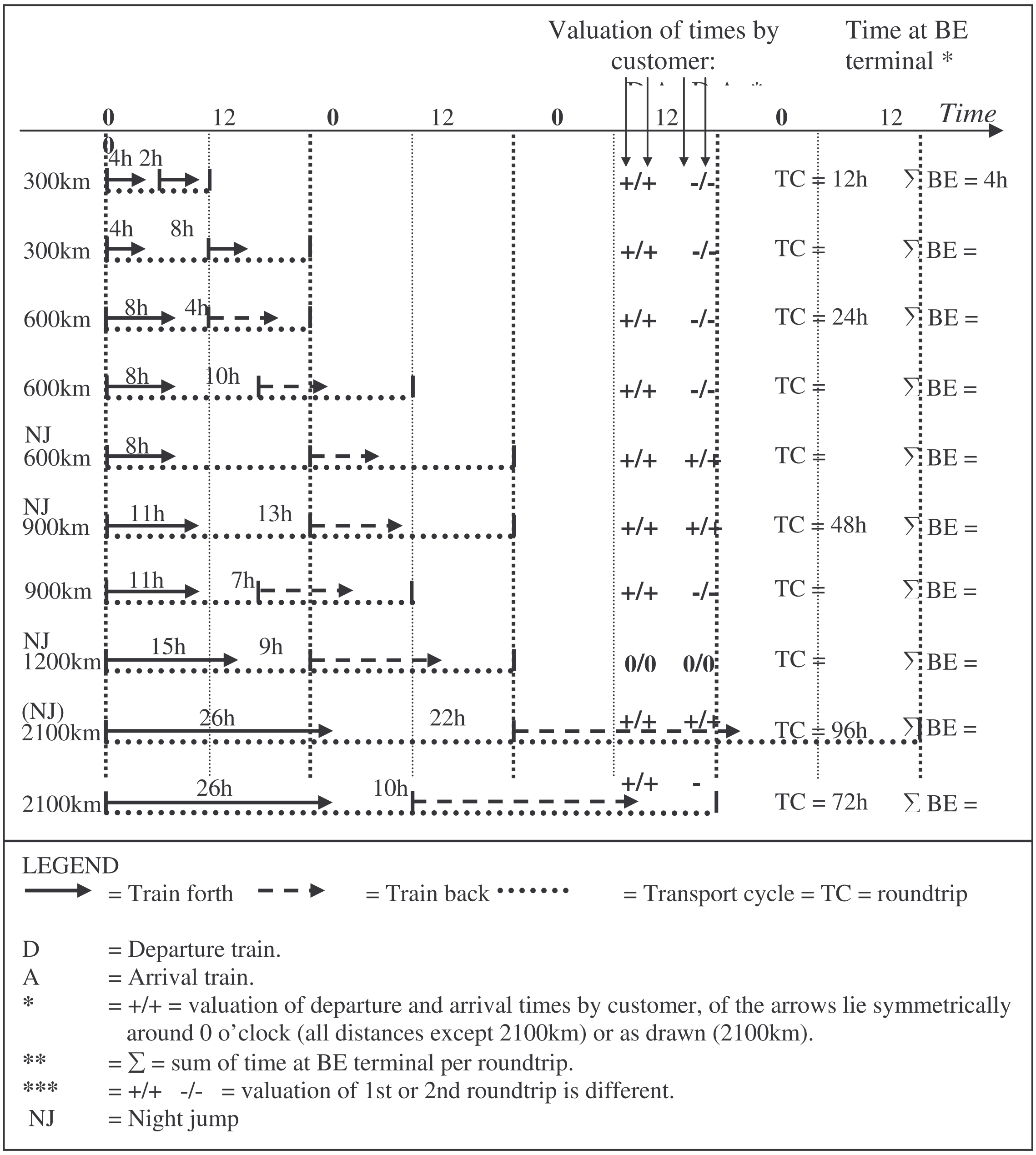

Fig. 1: Alternative train roundtrips per distance class (300 km, 600 km, 900 km, 1200 km and 2100 km) (average link speed = 80 km/hour).

At first sight, the frequencies appear to have a reciprocal value of the number of days of a roundtrip. A second look reveals that the frequency is often higher in order to achieve periodicity. The night jump with the roundtrip time of 48 hours only has a frequency of 0.5. If a counter train is inserted, the frequency is 1. Roundtrips of 36 hours require three parallel roundtrips in order to achieve periodicity. The frequency is then 2. Each second outbound train and each second homebound train then has a night jump quality. Further reduction of the roundtrip time is possible, but it implies an increase in frequency to, for instance, four or more (e.g. 12).

In practice, this is rarely possible, certainly not in BE networks. Complex bundling[23] could then be an interesting option. However, the prospect of higher frequencies may still be restricted because of competing objectives. If the network designer (train operator), when changing the bundling concept, can choose between an increase in frequency or an increase in vehicle scale[24], he will often choose vehicle scale; especially, if a frequency level of 1 (or even 2) is already present.

One could draw the following general conclusion: reduction of the roundtrip time of locomotives and wagons is highly relevant in cutting the costs and increasing the competitiveness of intermodal transport. A 24-hour reduction in the roundtrip time keeps frequency at a feasible level, certainly in combination with complex bundling. Short distances (e.g. 300 km) should not be covered purely by night jump operations, because this would waste time and significantly push up vehicle costs.

In some roundtrips vehicles will spend very short times at BE terminals. Short handling times can be facilitated by innovative operations and exchange techniques. These techniques, which are normally expensive, can also be justified for roundtrips, which do not require speed.

A differentiated pricing policy might be an interesting option here. A train operator would pay a higher transhipment price for fast handling and a quick return to the network than a train operator whose train has no need of such speed. The train operator would recoup the higher handling costs via the lower vehicle costs which are generated by saving time. The balance between higher terminal costs and lower vehicle costs should be neutral or positive.

4. The impact of complex bundling on distances and times of trains

4.1 Bundling triangle

Complex bundling is an operation in which goods with different origins (B terminals) and destinations (E terminals) are transported in common vehicles and/or load units for part of their journey. The potential advantages are lower unit costs due to scale, higher frequencies, more E terminals per B terminal and/or lower minimal network volumes[25], and eventually also an equalization in the time of exchange peaks at BE terminals. But there are also some disadvantages, notably additional exchange at intermediate nodes and longer distances (detours).

There is a quantitative relationship between three of the mentioned network design entities: network volume, vehicle scale and transport frequency. I shall call this the bundling triangle (Figure 2). A change in one of these three variables will cause a change in at least one of the others. The quantitative relation depends on the choice of bundling concept and the network concentration (= number of BE terminals).

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[23] These are consolidation networks with intermediate exchange nodes, as line networks or hub-and-spoke-networks. See also the definition in Section 4.1 and Figure 4.

[24] A combination of vehicle size and loading level.

[25] Whether these advantages can really be achieved, depends on the actual situation. Kreutzberger (2003) shows why in some situations BE networks, in others HS and in still others L, TCD or TF networks are best solutions.

Bundling networks can be compared by observing the impact of a change in the values of one of the triangle variables. In the frequency approach the frequency varies, in the volume approach the network volume varies and in the scale approach the transport scale varies[26].

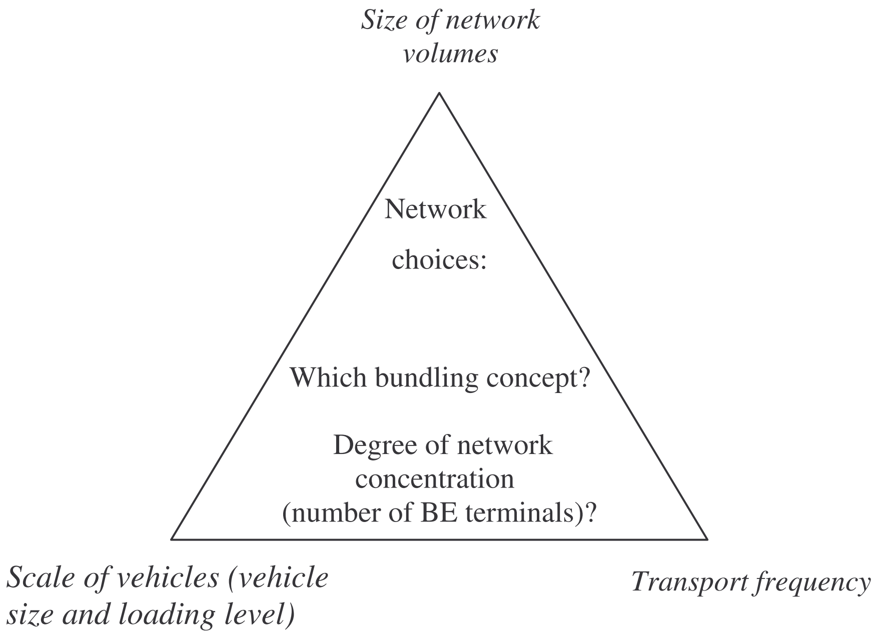


Fig. 2: The central entities of the bundling triangle**.**

4.2 Vehicle distances

In this section five bundling concepts are compared in terms of vehicle distances and times. The number of BE terminals and their location is the same in all the networks (Figure 3). Given X, Y, the number of BE terminals, the locations of intermediate exchange nodes, and the condition that only block trains/shuttles are employed in all parts of the network, it is possible to determine the vehicle distances.

The envisaged networks are so-called ***separated*** and ***directed*** networks. This implies that the outbound and homebound flows are served separately and that there are no flows between B terminals or E terminals.

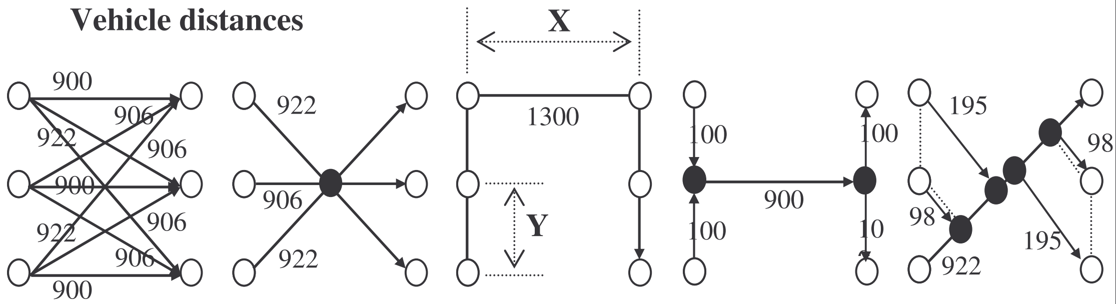
If the network volume (the number of load units from left to right in Figure 3) and the scale of trains in the trunk network is the same for all the bundling networks, then the frequency of an HS network is = 1/n of that of a BE network, and the frequency of an L, TCD or TF network is 1/n2 of that of a BE network, n being the number of BE terminals on one side of the network. This is the quantitative relation in the frequency approach so far. In Part B of Figure 3 the frequency of trunk trains in the HS network is three times that of the BE network; and in the L, TCD or TF network nine times that of the BE network. In other words, in each bundling network in Figure 3 there are nine trains between the B terminals and the E terminals: in the BE network they belong to one batch, in the HS network to three batches, in the others to nine batches.

[26] For a conceptual overview see Kreutzberger (2001 of 2003).

In Approach B the network distances can be used to determine the average detour factor of trains in complex bundling networks in comparison with the BE network; detour factors which are related to the length of routes (= route impact). These give an impression of the overall size of one of the disadvantages of complex bundling.

	Complex bundling networks			
BE network	HS network	L network	TCD network	TF network

Vehicle distances



A Total vehicle distance in the volume or scale approach (frequency = 1)				
8166	2750	1300 *(1)*	1300 *(1)*	1508 *(2)*
B Total vehicle distance in the frequency approach (frequency BE network = 1)				
f = 1	f = 3	f = 9	f = 9	f = 9
8166	8250	11700 *(3)*	11700 *(3)*	13572 *(3)*
C Distances for the calculation of vehicle costs in each approach				
907 = netw. average	917 = netw. average	1100 = netw. average	900; 100 trunk netw.; local	922; 98; 195 trunk netw.; local

LEGENDA
○ = BE terminal (in L network also L terminal), for multimodal , e.g. rail-road-transhipment.
● = Unimodal exchange node (terminal, shunting yard or siding), e.g. for rail-rail-exchange of load units.

(1) 900+400=1300.
(2) 922+2*(195+98)=1508.
(3) 9-fold of respectively *(1)* or *(2)* .

Fig. 3: Calculation of distances of single and all-network vehicles (in vehicle kms).

The characteristics of the networks in this figure are:

- directed network;
- separated network;
- geometry: X = 900 km, Y = 100 km, 3 BE terminals on each side of the network).

As already indicated, when introducing complex bundling networks, the network designer (e.g. train operator) will often focus as far as possible on a larger scale instead of higher frequencies. In this approach, the scale approach (Part A of Figure 3), the network volumes and frequencies are the same for all networks. Only the length of the trains and/or loading levels vary.

The scale is – in comparison with the BE network – n2 for the L, TCD or TF network and n for the HS network. The scale compensates for the difference between the number of branches (trains) in the trunk network (9, 3 or 1 respectively).

In the scale approach we see that the network distances (= train kilometres) are longest for the BE network, followed by the HS network. The network distances reflect:

- the number of trains (branches): fewer trains in complex bundling networks imply smaller network distances;
- the detour factor of complex bundling networks: the larger distance in complex bundling networks implies larger network distances.

In this example the first impact is clearly dominant. The shorter net distance of all network trains expresses more economies of scale in complex bundling networks in the scale approach. The shorter distances can only be realized within the technical constraint of maximal train lengths.

The question which now arises is whether the first component also dominates in other networks[27]. This question has been investigated by means of enumeration, by analysing about 150 geometrically varied networks. The networks have, besides the mentioned X values, the Y values of 25 km, 50 km, 100 km and 200 km. The number of BE terminals at one side of the network is 2 -10. The relative width of a network is that of a square, or $(\sum Y)/X \leq 1$.

The results are shown in Figure 4. This shows the distance detour factor of all trains in a complex bundling network compared with the reference BE network. In concrete terms: the distance of all trains (in train kms) in an L network with X=600 km, Y=200 km and n=2 is 0.4 times that of all trains in a BE network with X=600 km, Y=200 km and n=2.

This 0.4 can be split into two components:

- The impact of the bundling triangle: given that n=2 and 1/n2, this factor is 0.25.
- The route impact: this led the factor to increase from 0.25 to 0.4.

Figure 4 clearly shows that in all the investigated networks the impact of the bundling triangle is greater than the route impact. This even applies to the L and TF networks, which – given the geometry of the envisaged networks – have a relatively unfavourable layout.

[27] = with other X, Y, and/or number of BE terminals.

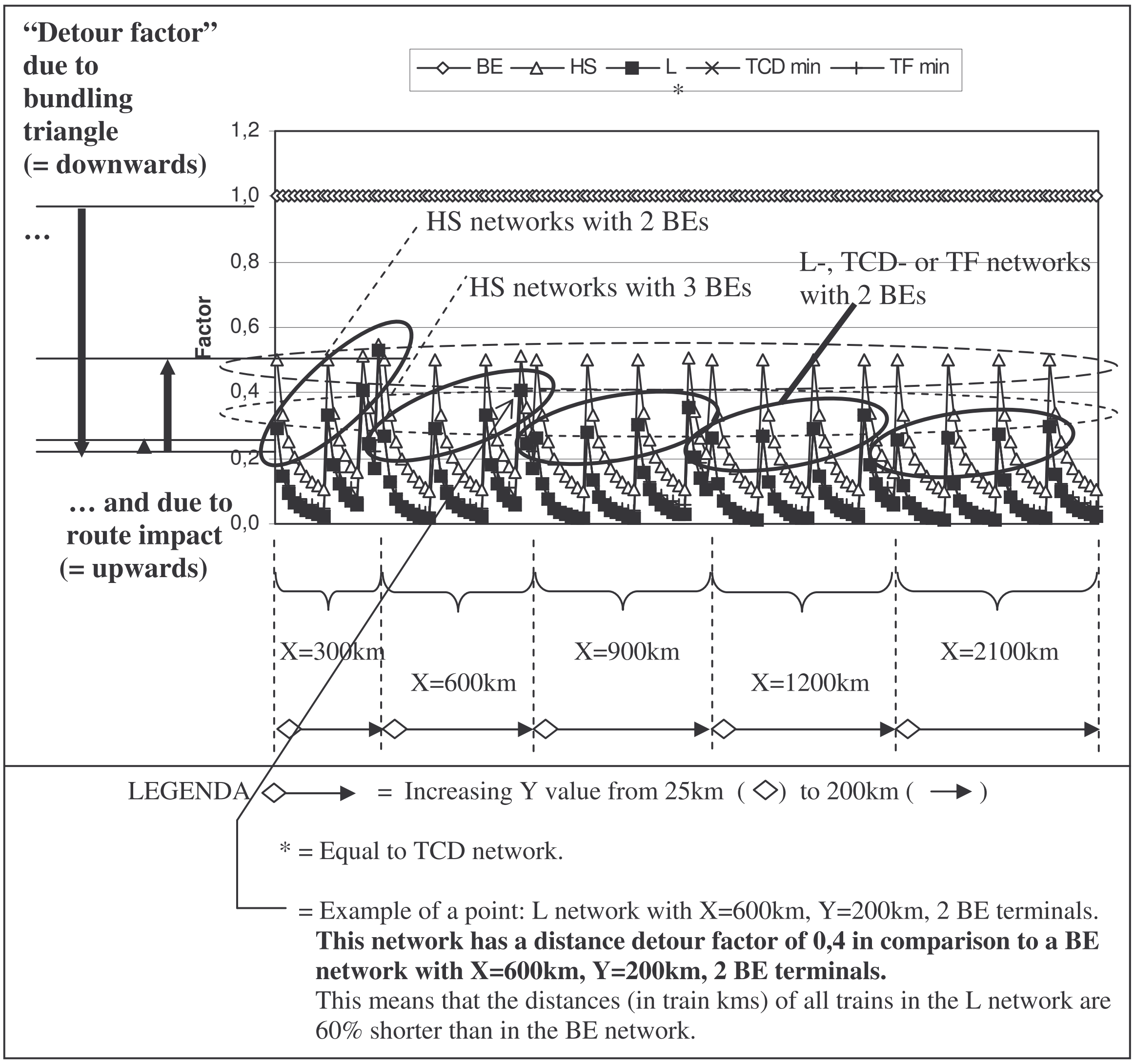


Fig. 4: Detour factors of vehicles (on the basis of Calculation A in Figure 3).

The dominance of the bundling triangle above the route length in the overall road detour factor is a key element in the advantages of scale which complex bundling can lead to. But certain comments also need to be made. The distance detour factor is valid for train kilometres but not for wagon kilometres. The trains have different scales. In the complex bundling networks the scale – within the technical constraints – is higher than in the BE network.

If the larger scale of trains only expresses the **train length**, the detour factor is only valid for the locomotive and the driver. There are no advantages of scale for wagons; the wagon kilometres are the same in all bundling networks.

However, if the larger scale of trains occurs in the direction of higher **train loading levels**, the detour factor applies to the entire train. In this case not only the locomotive or driver kilometres, but also wagon kilometres, are different per bundling concept. So, the advantages of scale apply to the whole train.

4.3 Vehicle times

The vehicle times show a similar picture, despite:

- node times, which decrease the weight of link times;
- the time inserted to make vehicle roundtrips periodic trips.

The impact of the bundling triangle is greater than the route impact. In the scale approach the overall time detour factor of trains in complex bundling networks is less than 1. In other words, we are dealing with scale effects[28]. The scale effects emerge for the traction and in the scale approach[29].

This picture emerges for relatively high and low average link speeds (40 km/h or 80 km/h respectively) with a relatively short duration time at BE terminals and intermediate exchange nodes[30].

4.4 Sub conclusion

In the scale approach advantages are discernible in:

- shorter distances of network trains (locomotives, and often wagons, drivers);
- shorter times for all network trains (possibly locomotives; wagons only to some extent).

This advantage emerges only within the technical constraints (amongst which maximal train lengths). It represents a balance between the advantages of the bundling triangle and the route detour disadvantages of complex bundling. The net impacts refer to vehicles and take account of links and nodes.

The balance in distance and time will be reflected in the vehicle costs. Cost savings from shorter network distances in complex bundling models must compensate for handling costs at terminals and other exchange nodes. If the savings are greater than the costs of node handling, the costs of complex bundling will be lower. Optionally, the time costs of shippers (Section 3) can also be included in the balance.

5. Conclusion

Low costs are the most important factors in transport performance for shippers and other customers of intermodal transport – all the more reason for investigating vehicle and transport costs[31]. This paper focuses on the analyses of vehicle costs. Time costs are strongly influenced by the vehicle roundtrip design. The vehicle roundtrip must be periodic so that the customer can recognize and understand the transport service. Next, departure and arrival times of trains, ideally, are well synchronized with the time pattern

[28] Again within the technical scale constraints.

[29] The reduction in the number of BE terminals or links in complex bundling networks is offset by the length of trains (= number of wagons). The number of locomotives and drivers stays the same.

[30] Primary and secondary handling per half roundtrip: BE network: 4 hours at BE terminals; HS network: 4 hours at BE terminals; 2 hours at the hub; L network: 1 hour at the BE terminals, 2 hours at all L terminals; TCD network: trunk train: 6 hours at TCD nodes; pair of local trains: 2 hours at BE terminals, 3 hours at op CD terminals; TF network: trunk train: 1 hour at BE terminals, 2 hours at all F nodes; pair of local trains: 1 hour at BE terminals, 1 hour at F nodes.

[31] Amongst which the costs of freight exchange at nodes.

of shippers. In this respect the periodic night jump of train services is a customer-friendly product: the departure of trains at the end of a day and arrival at the beginning coincides perfectly with the 8-hour economy, which is applied by many shippers. Another advantage of the night jump is that freight trains use tracks at times which do not interfere with passenger rail transport.

The disadvantage of the periodic night jump is – at least for many players – the waste of time. Many trains – usually the wagons but often the locomotives as well – just stand around ‘doing nothing’ for two-thirds of the roundtrip time. It is possible to speed up the roundtrip. But to restore periodicity, the frequency must often be increased. The volumes will often be insufficient for this.

A possible solution is to switch to complex bundling. The goods are then moved in, for example, hub-and-spoke or line networks instead of networks with direct connections. A fast roundtrip of vehicles can be achieved by increasing the average link speeds and/or by reducing node times. The minimal node time is the handling time plus the buffer time to compensate for unreliability. The handling time can be reduced by deploying innovative operations and techniques (e.g. new generation terminals). A point of attention is that nodes serve many trains/roundtrips, only some of which need to make a quick return to the network.

The impact of complex bundling networks, especially on vehicle distances and times, is the subject of the last part of the paper. The disadvantages of complex bundling, amongst which, longer train routes and the additional time and unreliability due to intermediate exchange nodes, seem to have penetrated the minds of decision-makers. This appears to be less so when it comes to the advantages of complex bundling.

Apart from the already mentioned perspective of a higher frequency by complex bundling, there still is the perspective of more scale. The vehicle scale is visible in the form of lower total distances and times for all network trains (locomotives and/or wagons, sometimes also drivers). An analysis of about 150 geometrically varied networks, which have more or less the same layouts as actual rail networks, showed that the shorter network distances of vehicles in complex bundling networks due to a smaller number of branches weighs less than the additional distance/time due to longer routes and additional intermediate nodes.

This advantage may – when calculating costs – compensate for additional node exchange costs at intermediate nodes in complex bundling networks. This last step is not elaborated in this paper.

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The importance of stakeholder analysis in freight transport

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Abstract

In this paper the multi actor, multi criteria analysis method or in short the MAMCA method is presented for the evaluation of transport project. In this method stakeholders are explicitly taken into account which is very important in the freight transport sector. Starting from an overview of evaluation methods, the paper comes to the integrated MAMCA approach. Several applications of this method are discussed.

Keywords: Freight transport; Evaluation methods; Multi criteria analysis.

1. Introduction

The evaluation of transport projects has become increasingly complex. Different aspects have to be taken into account and the consequences of the projects are usually far reaching and the different policy alternatives are numerous and difficult to predict. Several pressure or action groups have also emerged causing an even more complex decision making process. The use of multi criteria analysis for the evaluation of transport projects has increased due to this increasing complexity of the problem situation. The eclectic multi criteria analysis method developed by De Brucker (2000) for example enables to integrate different types of analysis tools used in transport project evaluation, such as the Environmental effect analysis, safety effects, economic impact analysis, etc.

At the same time, the importance of stakeholders within this evaluation process is been recognised. Research on transport projects is generally carried out to provide information to policymakers that have to operate within restrictive parameters (political, economical, social, etc…). Researchers should therefore take greater account of the different priorities of stakeholders such as policymakers, private enterprises and households (Van Ham and van Wee, 2003). These stakeholders should be incorporated explicitly in the evaluation process.

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The concept of stakeholders was first introduced in the management literature, where stakeholders have to be taken into account once a company or organisations has adopted the idea of corporate social responsibility (Donaldson and Preston, 1995 and Buysse and Verbeke, 2003). The broadest definition of the concept is found in the work of Freeman (1984) where a "stakeholder is by definition any individual or group of individuals that can influence or are influenced by the achievement of the organisation's objectives". In the context of transport policy this definition can be transformed in: stakeholders are those people who have a vested interest in a problem by affecting it or/and being affected by it (Banville et al., 1998).

Depending on the situation a more participatory process can be followed where the stakeholders can participate in the policy process (such as proposed by Rotmans and Van Asselt, 2000). The level of participation will depend on the resources and time devoted to the project, as it takes time and money to involve the stakeholders in the process. Also, not all stakeholders will be able or ready to participate in the policy analysis process and their participation might not even always be desired by the analyst. The participation of the stakeholders is however necessary if the quality of the decision can not be guaranteed by the analyst alone (because he or she has not the necessary information or if the problem is ill-structured). Consultation of the stakeholders or participation is then necessary. Another category of necessary stakeholder participation occurs when the decision is highly controversial and the acceptance rate low (Vroom, 1974). The most important is to identify them and to be aware of their stake and objectives. If the interests of the stakeholders are not taken into account the study or analysis will be ignored by policymakers or be attacked by the stakeholders (Walker, 2000).

In the next section the possible introduction of the concept of stakeholders in the existing evaluation tools for transport projects will be discussed. In section 3 a multi stakeholder, multi-criteria analysis methodology will be developed for decisions in the transport sector. Section 4 illustrates this methodology by applying it to some case studies.

2. Methods used for the evaluation of transport projects

Several evaluation methods can be employed for the evaluation of transport related projects. In this section an overview of these methods will be given and the adaptability of them to include the necessary multi-criteria, multi-stakeholder approach (as argued above) will be discussed. Five common used evaluation methods can be identified, namely the private investment analysis, the cost-effectiveness analysis (CEA), economic-effects analysis (EEA), the social cost benefit analysis (SKBA) and the multi criteria decision analysis (MCDA).

The private investment analysis (PIA) or private cost-benefit analysis, the cost-effectiveness analysis (CEA) and economic-effects analysis (EEA) are applied in specific cases. These three methods are however not interesting if we want to include stakeholders into the analysis. The Private cost-benefit analysis takes the pure financial cost and benefits of the project into account. It is being executed from the point of view of the private or public investor and does not take more broad objectives into account. The Cost-effectiveness analysis (CEA) looks at the effectiveness of the measure in terms of the costs that government puts in. The CEA has thus a uni-criterion, uni-actor perspective. It looks at the effectivity with regard to one specific goal. The economic-effect analysis (EEA) or Regional Economic impact study (REIS) looks at the projects' impact on added value, employment and fiscal revenue. Input-output tables are used and indirect effects are captured through the use of multiplicators. The EEA is specifically designed for the government perspective and takes only three criteria of this stakeholder into account (De Brucker et al., 1998).

The SCBA is grounded in welfare theory. It takes a wider societal perspective and in this sense it can also include the external costs of transport into the analysis. It is usually used when there are only a few possible alternatives to be examined. A discount rate is used to calculate the net present value and the internal rate of return of the project. All the costs and benefits have to be expressed in monetary terms. In some countries such as the UK, the social cost benefit analysis has been the only authorised evaluation model for transport projects. The aim is to come to a more comparable basis for different transport projects and to define to a framework of similar discount rates and appraisal methods. The monetarisation of all the effects however still remains a problem. Some of the external effects of transport are difficult to assess and translate in monetary terms (Button, 1993; Kreutzberger, Macharis and Woxenius, 2004). The SCBA is based on the compensation criterion. The introduction of a stakeholder analysis in a SCBA is in principle possible if the costs and benefits are structured according to the stakeholders. So for each stakeholder the costs and benefits would be listed and calculated. However, in the end of the process the costs of one stakeholder can be compensated by the benefits of another. The redistribution effects are not clearly coming out of such an analysis. This problem can be avoided by creating an end table per stakeholder so as to get a cost-benefit analysis of the project per stakeholder. The problem of monetarisation will however exclude many more subjective or qualitative costs or benefits from the analysis.

Multi criteria decision analysis (MCDA) provides a framework to evaluate different transport options on several criteria[1]. The idea of incorporating several decision makers in a multi criteria decision analysis is not new. Many methods have extended their methods and software for Group Decision support systems (GDSS). The PROMETHEE method for example has been extended in Macharis, Brans and Mareschal (1998); the Analytical hierarchy process (AHP) method in Saaty (1989), ELECTRE in Leyva-López and Fernández-González (2003). However the concept of stakeholders was not clearly defined in these extensions. The decision makers were referred to as players, parties or participants. The concept of stakeholders was first introduced in MCDA by Banville et al. (1998). As denoted by Banville et al. (1998) multi criteria analysis is useful for the introduction of the stakeholder concept. In their paper, a first framework for the introduction of the concept of stakeholders is introduced. They argue that certainly in the first three stages of a multi criteria analysis the concept of stakeholders can enrich the analysis, but they do not include the stakeholders within the methodology further on. In this paper a multi-stakeholder, multi-criteria analysis is proposed. It has been successfully applied in several projects for the evaluation of transport related strategic decisions.

[1] Some hundred methods exists for the aggregation of the evaluation (see Vincke, 1992 for an overview).

3. The multi-stakeholder, multi-criteria analysis evaluation framework

The methodology consists of 7 steps. The first step is the definition of the problem and the identification of the alternatives (step 1). The various relevant stakeholders are then identified as well as their key objectives (step 2). Second, these objectives are translated into criteria and then given a relative importance (weights) (step 3). For each criterion, one or more indicators are constructed (e.g., direct quantitative indicators such as money spent, number of lives saved, reductions in CO2 emissions achieved, etc. or scores on an ordinal indicator such as high/medium/low for criteria with values that are difficult to express in quantitative terms, etc.) (step 4). The measurement method for each indicator is also made explicit (e.g. willingness to pay, quantitative scores based on macroscopic computer simulation, etc.). This permits the measurement of each alternative performance in terms of its contribution to the objectives of specific stakeholder groups. Steps 1 to 4 can be considered as mainly analytical, and they precede the "overall analysis", which takes into account the objectives of all stakeholder groups simultaneously and is more "synthetic" in nature. Here, an evaluation matrix is constructed aggregating each alternative contribution to the objectives of all stakeholders (step 5). The MCDA yields a ranking of the various alternatives and gives the strong and weak points of the proposed alternatives (step 6). The stability of this ranking can be assessed through a sensitivity analysis. The last stage of the methodology (step 7) includes the actual implementation. The various phases are discussed in more detail below.

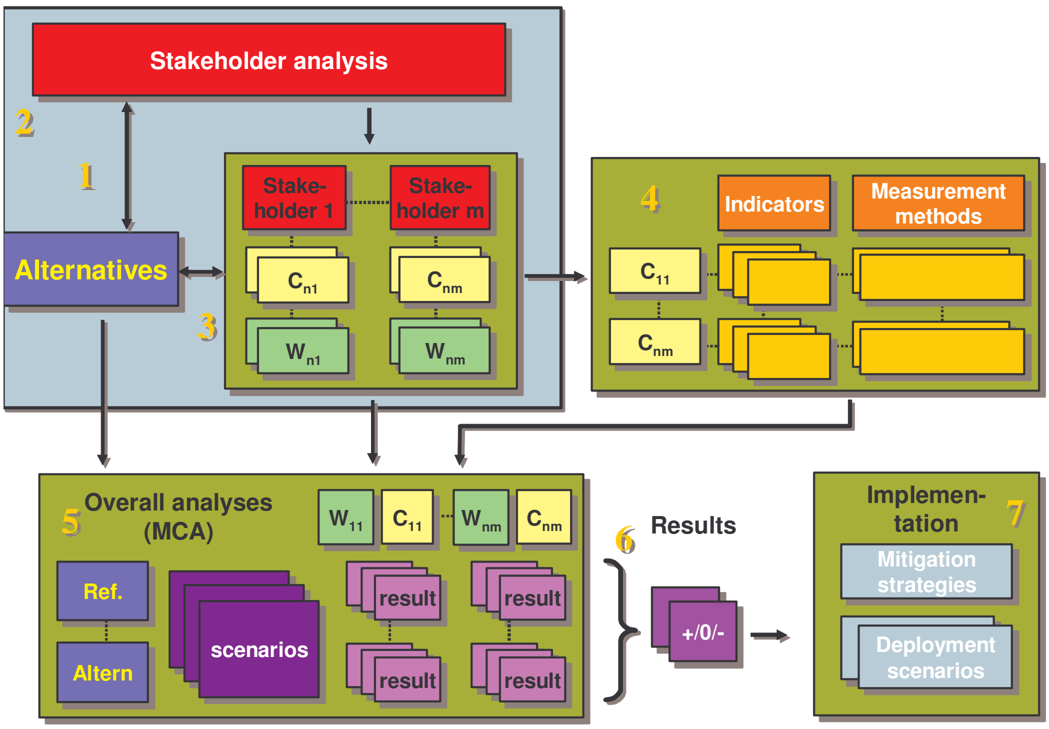

Fig. 1: Methodology for a multi-stakeholder, multi-criteria analysis (MAMCA).
Source: own set-up.

Step 1: Define alternatives

The first stage of the methodology consists of identifying and classifying the possible alternatives submitted for evaluation. These alternatives can take different forms according to the problem situation. They can be different technological solutions, possible future scenario's together with a base scenario, different policy measures, long term strategic options, etc. There should be minimum 2 alternatives to be compared. If not, a social-cost benefit analysis might prove to be a better method for the problem. In section 4 different examples are given.

Step 2: Stakeholder analysis

In the stakeholder analysis the stakeholders are identified. Stakeholders are people who have an interest, financial or otherwise, in the consequences of any decisions taken. An in-depth understanding of each stakeholder group's objectives is critical in order to appropriately assess the different alternatives. Stakeholder analysis should be viewed as an aid to properly identify the range of stakeholders to be consulted and whose views should be taken into account in the evaluation process. Once identified they might also give new ideas on the alternatives that have to be taken into account.

Step 3: Define criteria and weights

The choice and definition of evaluation criteria are based primarily on the identified stakeholder objectives and the purposes of the alternatives considered. A hierarchical decision tree can be set up (see section 4 for examples).

Several methods for determining the weights have been developed. The weights of each criterion represent the importance that the stakeholder allocates to the considered criterion. A description of these methods is given in Nijkamp et al. (1990) and Eckenrode (1965). In practice the pair-wise comparison procedure proves to be very interesting for this purpose. The relative priorities of each element in the hierarchy are determined by comparing all the elements of the lower level in pairs against the criteria with which a causal relationship exists. This pairwise comparison is done on a 1 to 9 scale.

In Table 1 several criteria (gj) are compared to each other in terms of their importance to the overall goal or focus F. PF(gj,gj') represents the preference intensity for a specific pair of criteria (gj, gj') in terms of the higher level element (c.q., the focus F). This preference intensity is measured on a scale from 1 to 9 as illustrated in Table 2.

Table 1: Pair-wise comparison matrix in the AHP.

F	g_1	…	…	$g_{j'}$	…	g_n
g_1	1					
…		[1]				
g_j			[1]	$P_F(g_j,g_{j'})$		
…				[1]		
…					[1]	
g_m						1

Source: Saaty (1988).

Table 2: Pair-wise comparison scale in the AHP.

Intensity of importance $Pg_j(a_i,a_{i'})$	Definition	Explanation
1	Both elements have equal importance	Both elements contribute equally to the criterion considered
3	Moderately higher importance of row elem. (RE) as compared to column elem. (CE)	Experience and judgment reveal a slight preference of RE over CE
5	Higher importance of RE as compared to CE	Experience and judgment reveal a strong preference of RE over CE
7	Much higher importance of RE as compared to CE	RE is very strongly favoured over CE, and its domin. has been demonstrated in pract.
9	Complete dominance in terms of importance of RE over CE	The evidence favouring RE over CE is of the highest possible order of affirmation
2, 4, 6, 8 (Intermediate values)		An intermediate position between two assessments
1/2, 1/3, 1/4, ... 1/9 (reciprocals)		When CE is compared with RE, it receives the reciprocal value of the RE/CE comp.
Rationals Ratios arising from the scale		If consistency were to be forced by obtaining *n* numerical values to span the matrix
1.1-1.9 For tied activities		RE and CE are nearly indistinguishable; moderate is 1.3 and extreme is 1.9

Source: Saaty (1988).

The applied multi criteria-analysis method and software (see step 6) allow an interactive process with the stakeholders in order to perform sensitivity analysis.

Step 4: Criteria, indicators and measurement methods

In this stage, the previously identified stakeholder criteria are "operationalised" by constructing indicators (also called metrics or variables) that can be used to measure whether, or to what extent, an alternative contributes to each individual criterion. Indicators provide a "scale" against which a project's contribution to the criteria can be judged. Indicators are usually, but not always, quantitative in nature. More than one indicator may be required to measure a project's contribution to a criterion and indicators themselves may measure contributions to multiple criteria.

Step 5: Overall analysis and ranking

The MCDA method used to assess the different strategic alternatives can be any MCDA-method. Most of the cases discussed below are analysed with the Analytical Hierarchical Process (AHP). This method, described by Saaty (1982, 1988), allows to built a hierarchical tree and to work with pairwise comparisons. The consistency of the different pair-wise comparisons as well as the overall consistency of the whole decision procedure can easily be tested in the AHP that can handle both quantitative and qualitative data, the latter being very important for transport evaluations. Certain criteria in transport concern ecological impact or road safety issues. These criteria are difficult to quantify. Moreover, the method is relatively simple and transparent to decision makers and to the public. The method does not act like a black box since the decision makers and the stakeholders can easily trace the way in which a synthesis was achieved. The AHP is supported by a user friendly software package (EXPERT CHOICE), which makes it possible to determine not only the overall priorities of the alternatives studied but also to investigate the sensitivity of the final ranking.

It is also possible to work via profile charts if the pairwise comparison proves too difficult to manage (see Dooms and Macharis, 2004).

Step 6: Results

The multi criteria analysis developed in the previous step eventually leads to a classification of the proposed alternatives. A sensitivity analysis is in this stage performed in order to see if the result changes when the weights are changed. More important than the ranking, the multi criteria analysis allows to reveal the critical stakeholders and their criteria. The multi-actor, multi criteria analysis provides a comparison of different strategic alternatives, and supports the decision-maker in making his final decision by pointing out for each stakeholder which elements have a clearly positive or a clearly negative impact on the sustainability of the considered alternatives.

Step 7: Implementation

When the decision is taken, steps have to be taken to implement the chosen alternative by creating deployment schemes. This implementation process can be complemented by cost-benefit analysis for well-defined projects.

4. Case studies

The methodology can be applied in a very broad range of applications. In the area of transport it can be used for the evaluation of transport policy measures (such as the evaluation of mobility rights (Crals et al., 2004), infrastructure projects or the evaluation of transport technologies (such as the evaluation of advanced driver assistance systems, see Macharis et al., 2004). In this section, several recent applications of the methodology will be discussed in the area of freight transportation.

The methodology was first applied to evaluate the location of intermodal terminals (Macharis, 2000 and Macharis, 2004). The so called LAMBIT-model (Location Analysis Model for Belgian Intermodal Terminals) provided the framework for the decision-making process on the location of new intermodal terminals. In a preliminary phase the traffic potential of the terminal projects is determined. In order to have a sustainable terminal, the traffic potential in the surrounding area of the terminal must be large enough to support it. Furthermore, the impact of the new projects on the market area of the existing terminals must be analysed. A network model allowed the determination of the traffic potential and the impact on the existing terminals. In the risk analysis, the proposed locations were screened according to pre-determined standards (large enough for an intermodal terminal, grants by the local district, ability to get permissions, etc.). In the next phase a more comprehensive evaluation of a discrete set of terminal projects was applied. The criteria used in this evaluation represent the aims of the parties involved, namely the users of the terminal, the operators/investors and the community as a whole. The results of the analysis of the affected parties are brought together in order to get a global ranking of the projects. A sensitivity analysis closes the procedure.

In Figure 2 the decision tree is given. This tree shows the three stakeholders with their respective criteria and sub-criteria. For every criterion and subcriterion used in the model indicators have to be chosen that makes it possible to evaluate the alternatives on these criteria.

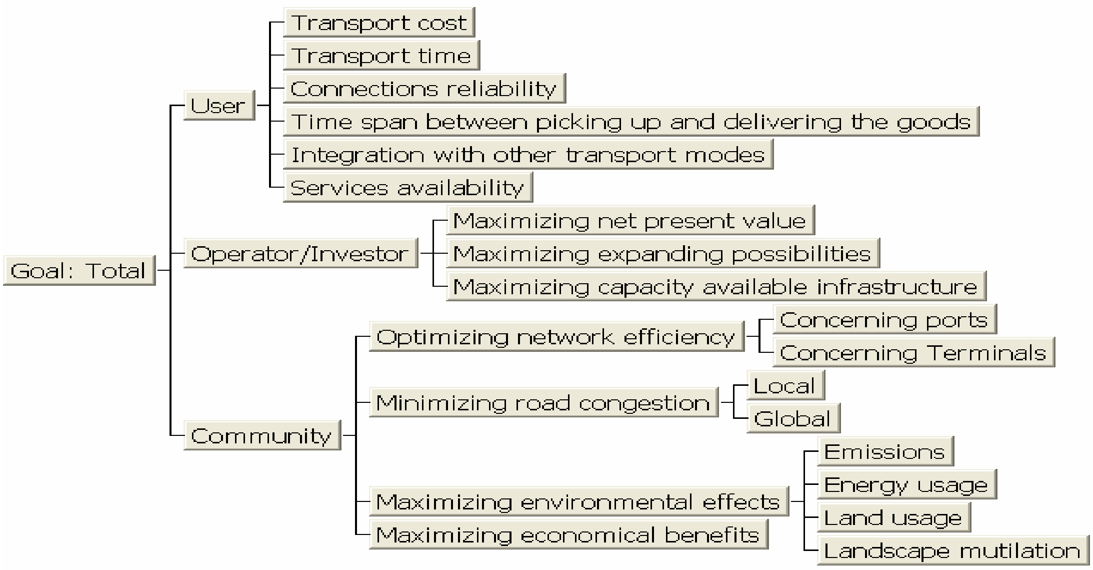

Fig. 2: Decision Tree in the LAMBIT-model.
Source: Own set up.

For the criteria of the operator/investor and more in particular the maximization of the net present value a cost-benefit analysis was used. The possible combination of multi-criteria with a cost-benefit analysis is very useful and expands the analysis. This combination of multi-criteria analysis, was also performed in the BRUGARWAT case study (Brussels Garbage by water), were the possible modal shift of waste transport in the Brussels region was analysed (Macharis and Boel, 2004). A social-cost benefit analysis was done in iteration with a multi-criteria analysis.

The social cost-benefit analysis made it possible to get an idea of the social desirability of the project, while the multi criteria analysis was used for the choice between the several possible types of package units that can be used. The alternatives were the ISO 20', 30' and 40' containers that compact the waste, ISO 40' open top containers and MSTS containers (multi service transport system) or bulk transport. For the Garbage operator (Net Brussel) the operational results (containers, ships, terminals, savings compared to road transport). For the local community the effects on visual intrusion, noise, smell and congestion are important. For the community as a whole the impact of the modal shift on accidents, global congestion, global noise, pollution and climate change were taken into account.

In the framework of the Masterplan of the Port of Brussels (Dooms, Macharis and Verbeke, 2004) the methodology was used in two types of applications. A first type of application was for a location analysis and planning for a separate port site (i.e. the site of Carcoke and Béco). In the Minimasterplan Carcoke for example the possible destinations of the site were compared to each other. The strategic alternatives were here an European distribution centre (EDC), value added logistics (VAL) or Recycling.

The second type of application was for the long-term strategic planning for the whole port area. For each port area the possible strategic development options were compared. This consisted of a pro-active and a status-quo scenario. Depending on the area different stakeholders were included in the analysis. Four main stakeholders are important in the context of port planning: government, local community, port authority and potential port users. A main stakeholder can be unbundled in several sub-categories with their own specific criteria (e.g. local community can be unbundled in tourists, residents, adjacent non-port firms and organisations) if the characteristics of a zone necessitate this approach. The definition of criteria for each stakeholder follows the approach followed for the definition of stakeholders: the criteria depend on the purpose, i.e. on the characteristics of each zone. This is very relevant for stakeholders, such as government and the local community, as their objectives often change throughout the port area. For example, in some port zones government objectives will be oriented towards economic development, whereas other port zones will be considered suitable for housing development and recreation. The objectives of the port authority and the port companies are much more stable, although there can be variations depending on port zone, but not as intense as for government or local community stakeholders. Another reason for this difference is that the port authority can be considered as ‘identical’ or ‘univocal’ over the whole port area, whereas the identity of local community stakeholders and sometimes even government (e.g. municipalities) can change depending on the considered port zone. The last step of the methodology consisted here in checking if the different strategic options proposed in each port zone were consistent with each other.

In Figure 3 the hierarchical decision tree is provided.

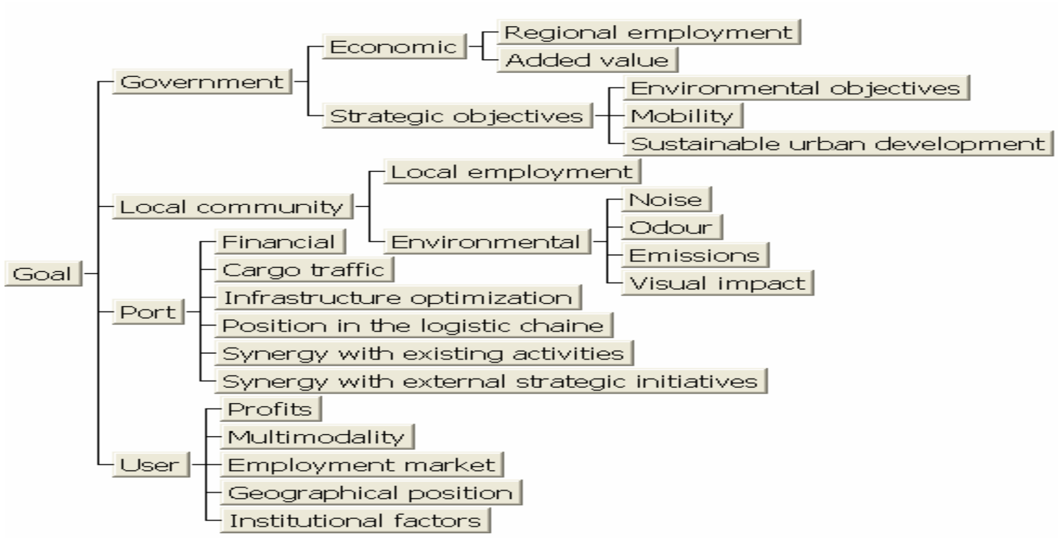

Fig. 3: Hierarchical tree for the Masterplan of Brussels (Béco dock).
Source: Dooms, Macharis and Verbeke, 2004.

The introduction of a new HST-terminal in Brussels (Macharis, Meeus and Dooms, 2004) was analysed according to the same methodology. Seven possible alternatives were proposed and compared. The stakeholders here were the railway operator NMBS, the government, the local community and the users. In Figure 4 the criteria for these stakeholders are given.

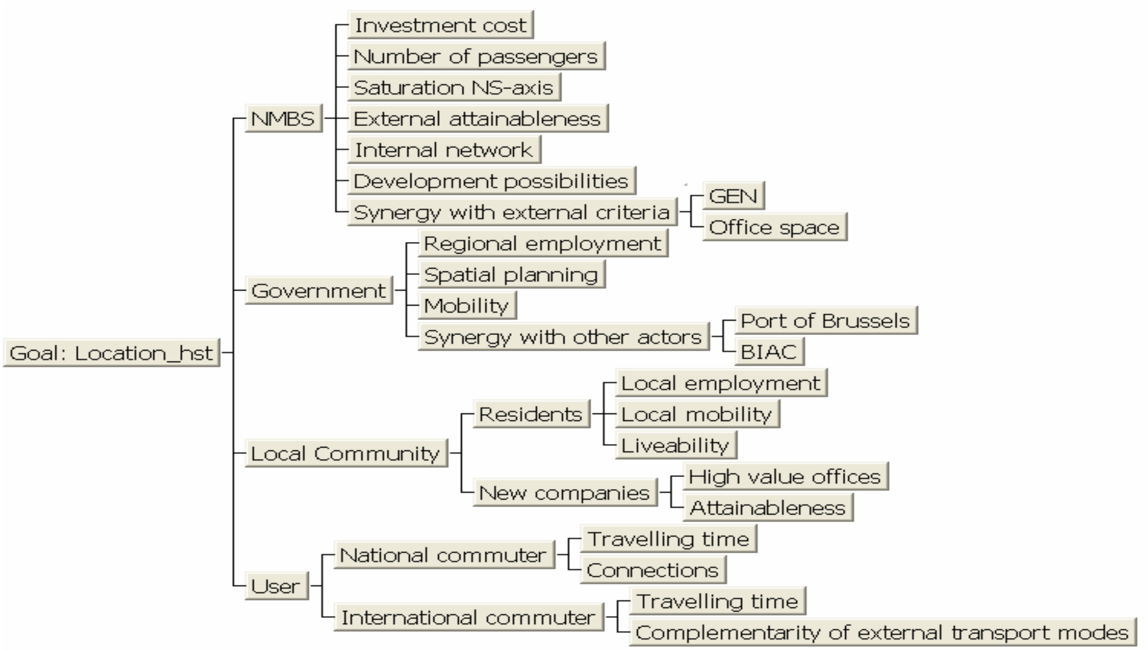

Fig. 4: Hierarchical decision tree for the evaluation of a new HST-terminal.
Source: Meeus, Macharis and Dooms, 2004.

A last and very interesting case was the evaluation of the possible extension of DHL at Zaventem International Airport (Verbeke, Dooms, Macharis and S'Jegers, 2004). This case has been reported extensively in the Belgian press during September and October 2004. The decision consisted in choosing between a pan-European consolidation strategy with Zaventem as superhub, a West-European expansion strategy with Zaventem as one of the multihubs or the further development of DHL in an external superhub, for example in Leipzig. The stakeholders in this case were DHL, BIAC the airport operator, the Government and the local community. Interesting in this case from a methodological point of view–next to the fact that the methodology highlighted very well the difficult decision making the government was involved in-was the introduction of time horizons into the analysis. With a 2012 time horizon (see Figure 5), the global preference was for the multihub expansion whereas when the time horizon moved to 2023 the global preference changed to the superhub (see Figure 6). This is due to the constraints of BIAC and also DHL itself to quickly grow in terms of capacity. In a longer timeframe, this does not pose any problems anymore.

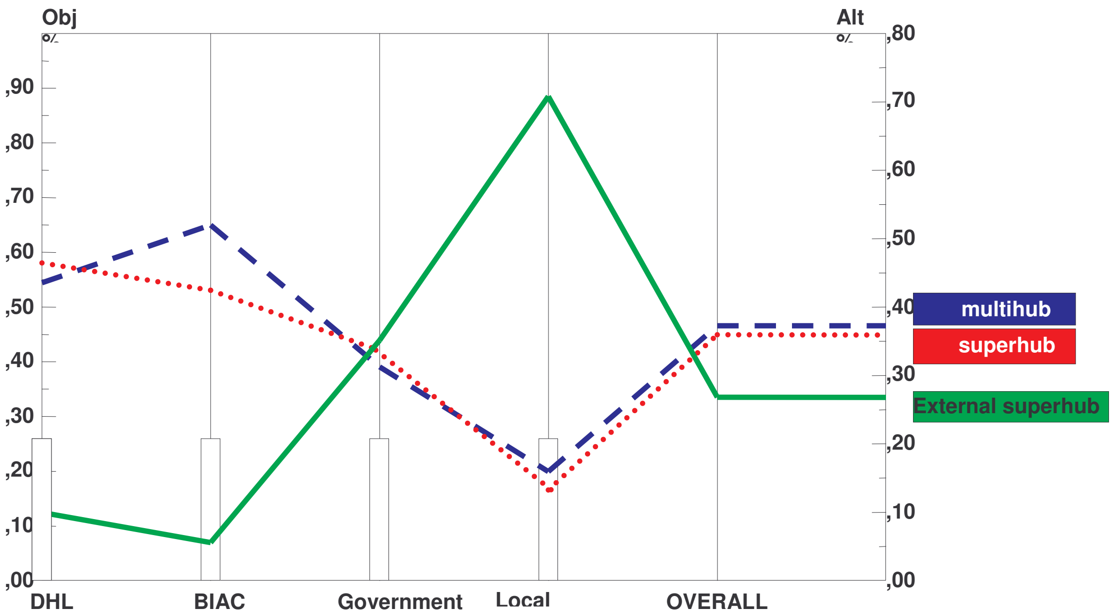

Fig. 5: The DHL case: time horizon 2012.

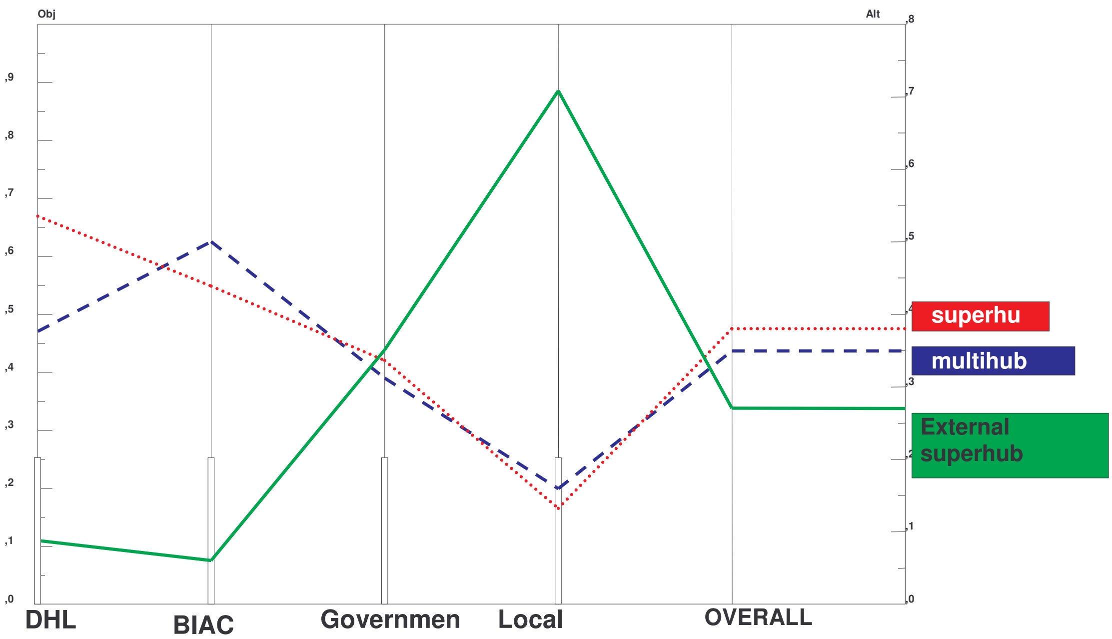

Fig. 6: The DHL case: time horizon 2023.
Source: Verbeke, Macharis, Dooms and S'Jegers, 2004.

The government had to provide a legal-institutional framework with horizon 2023 that could secure a long-term growth of the activity, especially after 2012. If not, the hub-activities of DHL would be relocated to another airport. In the short run, towards 2012, the multi criteria analysis showed that Zaventem had to be protected as a node in a multi-hub network of the company DHL.

5. Conclusion

For the evaluation of transport projects several stakeholders are involved and several criteria have to be included. The proposed methodology allows to incorporate these points of view and several criteria in the analysis. The methodology has been applied in a variety of projects, ranging from the evaluation of infrastructure projects to the evaluation of new technologies. Including stakeholders into the analysis takes more time in the beginning, but improve the likelihood of acceptance of the proposed solution will be higher in the end.

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