IMPROVING BALTIC SEA SERVICES – A QUANTITATIVE PLANNING APPROACH

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Abstract Reduction of inventories and optimum delivery of input goods are important parameters for efficient production processes. Therefore transport processes are a vital part of industrial production, and their features are important determining factors for production planning. Especially in the Baltic Sea region, short sea roro shipping connections are an important part of transport chains but also constitute a bottleneck through their restricted schedules. The attractivity of a short-sea roro shipping connection is determined through several factors. Among these are shipping prices, transport time, frequency but also factors that cannot be influenced by the ships operator, such as obligatory driver breaks for truck drivers, which use the shipping service, the geographical position of ports and the geographical position of logistics hotspots which determine the main-transport flows. A roro shipping service that is part of an optimal connection between two logistics hotspots would have a clear advantage on the market. The paper shall present a model that allows for the analysis of complete intermodal RoRo-shipping chains in regard to their attractivity for their end-customers. The model cumulates different features of a transport chain into one indicator. Thereby allowing the optimization of RoRo shipping connection towards customer needs.

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1. INTRODUCTION

A company acting on a free market needs to offer a product with clear characteristics which constitute an advantage for a customer, compared to competing products. At the same time the company has to strive for a profit in order, not only to survive, but also to grow.

The Baltic Sea constitutes a natural Barrier between Scandinavia and Central Europe, so that RoRo-ferry Services (sea going vessels specialised on transporting vehicles, such as trucks) have little competition from other transport modes when it comes to transports from Central Europe to Scandinavia (though land connections exists). However, the ferry services still have a commodity-character, as service features only differ slightly. This rises the question, how a shipping company can design a RoRo-transport product that still is „better" than competing products.

The paper at hand shall describe a model that allows for quantifying the qualities of a transport product from a customers view. This model allows for planning according to an indicator, that includes cost as well as time and frequency aspects, in comparison to competing products. It therefore allows the identification of RoRo-ferry services that offer a customer a clear and distinctive benefit in comparison to competing products. The customer view in this case, shall be the view of truck operators, which have to fullfill certain requirements (low transport prices, transport time windows etc.) of their own customers, and who will use the RoRo-ferry service that meets their own requirements best. They will naturally seek out cheap services, but also decide upon time factors. This does not automatically mean, that they will choose the quickest ferry service, as other factors play into the time factor as well (for example obligatory driver breaks and delivery time windows).

2. MODEL STRUCTURE

2.1. General Structure

A number of studies have been concerned with the question, which product features are important to the customer of a transport service.

Bühler (2005) found costs, time of delivery and transport time to be the most important determining factors for the selection of a transport service, whereby transport costs were clearly more important. Beute et al (2003) and Leyn (2010) found costs to be most important, followed by transport time. Geiger (2011) found long transport times and costs to be the strongest barriers for using alternatives to road transport, again indicating that these two factors are the two most important to a customer. Ludvigsen (2006) found costs to be as important as reliability, but this study was conducted in a European context, while the aforementioned were conducted within a German context. Most of this studies also identified other decision factors, but the importance of this factors were smaller than that of costs and transport time and the results on the ranking order were not as clear. This can be partly explained by the structure of the studies, which all examined the cost and transport time factor but laid different emphasis on the examination of other factors.

Bühler calculated demand-elasticity-factors for different decision variables. These factors are in so far interesting, as they allow a clear quantitative assessment. These elasticity factors shall also be used in the model described in the paper at hand. As Bühler found transport costs, time of delivery and transport time to be most important, the model shall be based on these factors. Service frequency shall be included as a determining factor for transport time (as a ferry-sevice-frequency leads to waiting times at a port). Delivery time shall also be modeled as part of total transport time, as explained below.

Figure 2 shows the general layout of the model. Cost- and timetable-submodels exist that provide cost and time data. The timetable models provide utilization data, that are then used in the cost models (compare following sections). Costs are calculated per vehicle and trip, while the timetable models provide data about the total transport time of a load unit (e.g. a trailer or swap body) and the arrival time at the destination.

In the paper at hand a „transport chain" usually consists of a (road transport) tour of a truck from its departure point to a port, a transshipment process onto a RoRo-ferry, the RoRo-ferry transport across the sea, a transshipment process from the RoRo-ferry at the destination port and a (road transport) tour of the truck to its destination.

Differences between transport chains are calculated for transport-costs, transport-times and arrival-times and the determining factors of the ferry service (price, transport costs, covered distance, positions of ports in the road network, service frequencies). These value differences are than used to calculate an attractivity indicator A, which predicts if a chain will be more or less attractive than alternative chains.

2.2. Modeling costs

The annual costs for operating a truck are being calculated through the following function (also compare Michalk, Meimbresse 2012):

$$C_{Ai} = C_{SIai} + C_{Mai} + C_{Di} + C_{Ei} + C_{Ii} + C_{REi} + C_{Oi} + C_{Ti} + C_{Ini}$$

The costs per trip can then be calculated as:

$$C_{Ri} = C_{Ai} / n_{Ri}$$

As the transport chain is described by the costs of truck transport and RoRo-ferry transport, in this model, the costs of a transport chain (per trip) can be calculated as :

$$C_{IT} = C_{tj} + \sum C_{Ri}$$

Whereby:

C_{Ai}	*Annual operating costs*	C_{REi}	*Costs of reserve*
C_{Ri}	*Trip costs per truck.*	C_{Ini}	*Insurance*
C_{SIai}	*Annual investment cost*	C_{Ti}	*Taxes*
C_{Mai}	*Annual maintenance costs*	n_{Ri}	*Number of trips*
C_{Di}	*Personnel costs for driver*	C_{tj}	*Total transport price of RoRo-service.*
C_{Ei}	*Energy costs*	C_{IT}	*Total transportation costs*
C_{Ii}	*Infrastructure costs (usually road tolls)*	C_{Oi}	*Overhead costs*

2.3. Time calculations

The total transport time along the transport chain can be calculated as:

$$t_{Total} = \sum_{i=1}^{n} t_{Ri} + \sum_{j=1}^{n} t_{Bj} + t_{RoRo}$$

With:

t_{Total}: *Total transport time from the departure point of the consignment to its destination.*
t_{Ri}: *Actual driving time of the truck under own power on road legs i.*
t_{Bj}: *Obligatory driver breaks j, as defined in* EU-Regulation 561/2006.
t_{RoRo}: *Time for transshipment and transport on a RoRo-ferry.*

The EU-Regulation 561/2006 from the 15th of March 2006, describes the rest- and driving period regulations (EC561/2006):

- A driving period shall not be longer than 4.5 hours, without a break.
- After a driving period of 4.5 hours the driver has to take a rest of at least 45 minutes.
- This 45 minutes break can be taken as a co-driver in the travelling vehicle. If the vehicle is being loaded or unloaded and the driver knows the time of the procedure beforehand, the loading/unloading time can count as such a break.
- A driver is allowed to drive a maximum of nine hours per day (this time can be extended to ten hours, twice a week). He has to take a daily break of at least 11 hours per 24 hour timeframe. He is not allowed to take this 11-hour-break as a co-driver, so he has either to sleep outside the vehicle or in the standing vehicle.
- The total driving time within two weeks shall not exceed 90 hours.

The service freuqency of a RoRo-ferry service finds expression in the transport time as well: The frequency is expressed as an average waiting time for a ferry service. The average waiting time t_{freq} results from a given service frequency and can be calculated through the time between two ferry departures:

$$t_{freq} = \frac{t_{freq}}{2}$$

As industrial companies as well as companies selling goods often have given production or selling timeframes, there is a useful delivery time, for a product. If a company produces or sells products between 6:00 AM and 8:00 PM, it can be argued that a delivery early within this timeframe is of more use, than a delivery late within this timeframe. Often, deliveries outside this timeframe could be of even lesser use, as they might cause additional cost for handling, which within the timeframe would be done by staff anyway on duty. So for this model a "useful delivery timeframe" shall be defined between the beginning of a useful delivery time frame T_{wB} and the end of this timeframe T_{wE}. Deliveries outside this timeframe would always lead to additional waiting time t_w.

The waiting time can be calculated as the time-difference between the actual arrival time T_A and the beginning of the useful delivery timeframe:

$$t_w = T_{wB} - T_A$$

The additional time components are added to the total traveltime t_{Total} and results in the total delivery time t_D:

$$t_D = t_{Total} + t_{freq} + t_w$$

2.3. Combining demand effects

One indicator shall include both factors (total delivery time and transport costs). The reaction of customers to alterations of one feature in a given service can be described with an elasticity function (compare for example Bücker 1998):

$$\varepsilon = \frac{\Delta x}{\Delta y} * \frac{y_1}{x_1} \tag{1}$$

With:

ε:	*Elasticity*
Δx:	*Absolute change of demand*
Δy:	*Absolute change of demand-factor*
x_1:	*Demand before change of demand factor.*
y_1:	*Demand factor before change of demand factor.*

The above equation can be transformed in order to calculate a change of demand based on a given elasticity:

$$\Delta x = \varepsilon * \Delta y * \frac{x_1}{y_1} \tag{2}$$

The demand factor could be a price or transport time, i.e. changing the price would change the demand.

In the study at hand, changes of transport costs, shall be equated with changes of service prices, e.g. an increase of the operational costs by 5% would lead to an increase of the service price of 5%. This assumption is quite realistic, as expert knowledge implies that the transport market is a buyer market. Different transport operators have explained, that they aim at prices, which allow for a return on sales of about 4%, which means, that they indeed orientate prices on the operational costs.

By inserting cost and time factors into equation (2), demand changes can be calculated based on transport-cost, transport-time and transport frequency changes:

$$\Delta x_c = \varepsilon_c * \Delta c * \frac{x_1}{c_1} \tag{3}$$

$$\Delta x_t = \varepsilon_t * \Delta t * \frac{x_1}{t_1} \tag{4}$$

With:

x_1:	*Demand before change of demand factor.*
Δx_c:	*Demand change based on transport cost change.*
Δx_t:	*Demand change based on total delivery time change.*
Δc:	*Absolute Change of transport costs.*
Δt:	*Absolute Change of total delivery time.*
c_1:	*Operational cost of service 1.*
f_1:	*Service frequency for service 1.*
t_1:	*Transport time of service 1.*
ε_c:	*Transport cost elasticity.*
ε_t:	*Transport time elasticity.*

In the study at hand, demand effects of transport cost and transport time changes, which occur through changing from one transport system to another, shall be calculated by adding the demand changes:

An attractivity indicator shall be defined as:

$$A = 1 + \Delta x_t + \Delta x_c \tag{5}$$

Furthermore, a Baseline Indicator A_{Base}=1 shall be defined for a given baseline transport chain. A transport chain superior to the baseline transport chain would be indicated by a demand indicator *A>1*, a service inferior to the baseline chain would be indicated by *A<1*.

2.4. Determining a superior transport service

Bühler (2005) described elasticity-values that explain how the demand of shippers grows or shrinks depending on the alteration of the transport time, the alteration of the transport price of a service and the alteration of service frequency (among other factors). He ascertained an elasticity of -1.6319 for transport price changes in intermodal transport, which implies an elastic demand. This means that the demand reacts rather strong, when prices rise. An elasticity of -0.5251 was determined for transport time changes in intermodal transport. This implies a rather inflexible demand: the demand does not react very strong, when transport times rise.

The optimization problem can be described as follows:

$$Maximize\ \{A \ = 1 + \Delta x_t + \ \Delta x_c\}$$

Different transport chains (with identical departure and destination points) can be examined, until a service with a maximum value for *A* is found. If the services differ only due to different ferry services, the ferry service belonging to the chain with the maximum value for *A* can be determined to be superior to the other services examined, at least for the transport chain examined. If a large number of possible transport chains are examined (with a large number of different departure and destination points), RoRo-ferry services that lead to a maximum value for *A* for a large number of transport relations or for a large number of customers, can be deemed superior.

3. PRACTICAL APPLICATION

3.1. Comparing and improving services

Three ferry-services shall be examined as an example for the paper at hand. The examination is based on a transport relation from Dresden (Germany) to Göteborg (Sweden). For the cost calculation a MAN TGX 18.400 truck with a Cargobull S.KO trailer is assumed. Ferry prices and schedules are based on the Scandline Services as of July 2012. In all cases the truck is assumed to leave Dresden at 6:00 AM.

The baselineroute with A=1 does not utilize ferry transport, but takes the landroute via Hamburg and the Great Belt.

The three ferrylines allow for three different transport routes:

1. Dresden - Rostock – Gedser – Göteborg
2. Dresden – Rostock – Trelleborg – Göteborg
3. Dresden – Sassnitz – Trelleborg – Göteborg

As the time aboard the ferry is, from a legal standpoint, a break time according to EC561/2006, they have to be calculated accordingly. This leads to the follwing travel times and total costs for the four routes (according to the above described time and cost models):

Table 1 Costs and time values four the four routes examined (own calculations)

	t_D [h]	C_{IT} [€]
Land Route via the Great Belt	32,50	1.377,92 €
via Rostock-Gedser	25,40	1.238,85 €
via Rostock-Trelleborg	25,20	1.205,57 €
via Sassnitz-Trelleborg	24,25	1.218,34 €

According to equation (6) and the described elasticity values, this leads to the following values for A:

Table 2 A-values according to the attractivity model (own calculations)

	A
Land Route via the Great Belt	1,00
via Rostock-Gedser	1,28
via Rostock-Trelleborg	1,32
via Sassnitz-Trelleborg	1,32

As all examined services are offered by the same shipping line, it is no surprise, that the A-Values, especially on the route from Rostock are very similar, so that the service do not compete with one another. This can be also be seen in the slightly higer price for the service between Rostock an Gedser (in comparison to the Rostock – Trelleborg service), though the distance between Rostock and Gedser is much shorter. A fact that could imply that optimizations have already been made.

3.2. Examining transport systems

The model can also be used to examine a large number of possible connections throughout geographical regions. The attractivity value could than be calculated as a cumulated and weighed value. The weights would represent the probable transport demand in the particular departure or destination point. The demand can be ascertained through the gross value added (of the first and second economic sector) of the destination or departure region (compare for example, Michalk, Meimbresse 2010). If the strenght of the transport flows from all originating point are known, a weight w can be calculated as:

$$w = \frac{F_i}{\sum F_i}$$

With:

Fi: Strength of transport flow from a particular point i (e.g. in number of standard trailers).

This weight can then be used to calculate a weighted Attractivity A_w indicator for all examined relations and for each examined ferry service:

$$A_w = \sum_{j=1}^{n} w * A_j$$

A ferry service with a higher A_w value can than be deemed superior than a service with a smaller Aw value, based on a large number of transport routes and thus based on a broad potential customer base.

The model can be used to find optimum prices, frequencies and travel-times in order to optimize a service towards competitiveness.

This application of the model can be found in large EU-Projects, such as FLAVIA or Scandria, where complete transeuropean transport-systems are the subject of examination and improvement. It is also a viable approach to develop new Ro-Ro-ferry services.

4. CRITICAL DISCUSSION AND CONCLUSIONS

Using Bühlers elasticity values with equation (5) is not without problems; as the elasticity values have been determined independently from each other. A customer that would not ship his goods with a given service when the price increases, might be completely insensitive towards a change in transport time when his shipment is not time-sensitive and vice-versa.

This indicates the necessity for further examinations in this area, in order to determine true more-dimensional demand patterns of shippers. Such an examination should be designed in order to lead to a multi-attribute compositional model. Such an analysis would present survey participants with a number of possible services, each consisting of different combination of features, which constitute different tradeoffs to each other.

However, it can be argued, that the elasticity values used here still depict the different importance of the features “transport-time” and “transport-price”. Also the demand estimation does aim at a large number of potential shippers, thus meaning, that for any customer who would not ship his goods after the transport price increases, another customer might just choose this service because of a simultaneous decrease in transport time. A high importance of lower transport prices would then lead more customers to use a different service, while the number of customers attract by the now changed service would be smaller, which is implied by the lower transport-time-elasticity. In conclusion, the demand indicator might not be a reliable parameter to estimate exact demand-developments, but it still can be used to make qualitative statements about the superiority of a service as compared to a competing service.

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BIOGRAPHICAL NOTES

Philip Michalk studied transport engineering and economics at the Technical University of Berlin and worked with the department of Track and Railway Operations, before joining the the Research Group Transport Logistics at the Technical University in Wildau. His research comprises the fields of service planning in transport and logistics and the development of key figure systems for transportation planning.