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List of submissions

New conference submission is not available

Cost and time models for road haulage and intermodal transport using Short Sea Shipping in the North Sea Region

Submission-ID 156

Paper status Accepted

Comments The paper is interesting as well as the empirical application of the proposed model. But I have two suggestions to the author/s in order to improve the paper: 1) the introduction is too long and the theoretical issues should be better emphasized in a separate section. The author/s should add a new paragraph dealing with the topics of SSS and motorways of the sea and the models already used for the analysis of their "sustainability" in the European context. 2) While the method and the models of analysis are well addressed described as well as the case study, then the conclusions and further research directions are very scarce and less developed. The added value of the paper, in practical and theoretical terms, is particularly relevant for the IAME, as the conference brings together the business reality and the scientific community.

Submission [\[Export as PDF\]](#) [\[Export as HTML\]](#)

Full paper [full_paper_u0155_s0156_Martinez_Lopez_Alba.docx](#) (uploaded on 15-02-2013)

The Sensitization of optimization models of fleets for sea motorways Lessons from the analysis of the fleet for the sea motorway: St.Nazaire-Vigo.

Submission-ID 153

Paper status Accepted

Comments The topic is interesting although there is already much work on the assessment of the competitiveness of multimodal transport. Is sensitization really the word that can be used here? 1) The research seems to build on earlier own work. For an publishable academic paper this should be made more "stand alone" by grounding the starting points also with references to other studies in this field. Main comments are on clarification of the methods, inputs, variables and lines of argumentation: 2) The text is not always clear which should be

improved: f.e. the second and third sentence of the second paragraph at page 3 are hard to understand. And the text needs a check on consistency: sensitivity or sensibility, conventional fleet or commercial fleet. And there are more 3) Description of the route: what is included, what not? . (f.e. are trucking costs incorporated in the sss trajet?) 4) Description of the variables:f.e . what does road costs incorporate? 5) Competitiveness is solely related to time and costs, as such most important variables. But how about reliability? 5) Description of formula's: what is IPT, what does this formula expresses? 6) Explain table 1 7) The paper does not explain why the sensitivity of the optimized fleet to the variables would be different than the commercial fleet. And also not why it is relevant to make this comparison. 7) The conclusion is not clearly explained and difficult to understand. 8) The concluding part at the last page is quite evident: if you determine competitiveness by relating the performance of one against the other, the performance attributes of the other are highly determining. .

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International Association of Maritime Economists Conference

3-5 July, 2013

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THE IAME2013 ANNUAL CONFERENCE

The [International Association of Maritime Economists](#) was founded in the early 1990s. IAME is an international forum for the exchange of research and information among those interested in maritime and maritime-related issues. The Association currently has a membership that includes over 500 individual members from all continents and more than 20 corporate members.

Jointly organized by [Euromed Management](#), [IFSTTAR](#), the [University of Genoa](#), and the [University of Naples Parthenope](#), the XIX annual IAME Conference will take place in Marseille, France.

Organizers invite authors to submit scientific papers related to this year's conference theme: ***Managing complexity in shipping and port markets: firms' business models, co-opetitive games and innovative public-private interactions.***

We look forward to welcoming you to Marseille.

Professor P. Cariou, Euromed Management

Professor E. Musso, University of Genoa

Associate Professor C. Ferrari, University of Genoa

Assistant Professor F. Parola, University of Naples Pathenope

Research Unit Director E. Gouveral, IFSTTAR-SPLOTT, Paris Est University, IAU-Idf

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June 2013 - Programme draft

The Programme draft is available at: [Program session draft](#)

APRIL 2013 - MEL PhD Prize competition

MARITIME ECONOMICS AND LOGISTICS (MEL) www.palgrave-journals.com/MEL

5th MEL PhD COMPETITION (2011-2013) - THE 'PALGRAVE MACMILLAN' PRIZE IN MARITIME ECONOMICS & LOGISTICS (MEL)

In pursuit of its commitment to promote quality research and strengthen research links, particularly among young researchers, MEL organizes its fifth Competition for the best PhD Theses that have been successfully defended during the period 1st July 2011 to 28th February 2013. Submissions will be peer-reviewed by an international Jury composed of:

Professor Hercules Haralambides, Erasmus University Rotterdam, NL

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Professor Thanos Pallis, University of the Aegean, Greece

Professor Photis Panayides, Cyprus University of Technology, Cyprus

Professor Ross Robinson, Victoria University, Australia

Professor Anna Sciomachen, University of Genova, Italy

The « Palgrave Macmillan » Prize for the best PhD thesis, accompanied by a prize of € 1,000, will be awarded at a ceremony that will take place in July 2013 during the annual conference of the International Association of Maritime Economists (IAME), in Marseille (www.iame2013.org). The five short-listed authors are expected to either join the IAME annual conference to present their work in a special session or arrange for suitable representatives to present on their behalf.

Authors should submit an electronic copy of their thesis plus an approximately 6,000-word paper of publishable quality, encapsulating the essence of the thesis (particularly the methodological part). Literature review should be limited to the absolute minimum, i.e. to works that bear directly upon the development of the thesis. MEL's *Instructions to Authors* can be found on the journal's website. Thesis and paper can be emailed to Dr. Francesco Parola, « Parthenope » University, Naples, Italy (francesco.parola@uniparthenope.it) and Prof. Claudio Ferrari, University of Genova, Italy (ferrari@economia.unige.it) no later than the **15th of April 2013**. Submissions should be accompanied by a letter from the competent university authorities confirming that the PhD thesis was defended after 1st July 2011.

NOVEMBER 2012 - Abstract Selection

The IAME 2013 organizing team gathered in Genoa on November 22-23, 2012. Claudio Ferrari (University of Genoa), Francesco Parola (University of Naples Parthenope), David Guerrero (IFSTTAR) and Pierre Cariou (Euromed Management) met to validate the results from reviewers of the 325 abstracts submitted to IAME2013 (276 abstracts were accepted). The organizing committee expresses its sincere gratitude to the 108 reviewers who participated in this first round of evaluations. Out of the 325 abstracts submitted, authors (based on 1st author's country of origin) are from 46 different nationalities: 24 from Greece, 16 from China, 18 from Italy and 16 from South Korea. Out of the 26 different topics selected by organizers, the most selected sessions are: Port Development and Performance (32 abstracts), Maritime Business Strategies (27) and Port Reform and Governance (25).

The second round of IAME2013 full paper submissions is now open. We would like to remind you that the deadline is February 15, 2013. The formatting requirements are described on the website and can be found at Call for papers.

SEPTEMBER 2012

IAME2013 organizers officially launched the 2013 conference with a presentation to IAME members during the closing ceremony of Taipei 2012. [ConferenceIAME2013- PPT Presentation](#).

Congratulation to Professor Paul Lee and to the IAME2012 organizing team for their successful conference and welcome to Marseille!



JUNE 2012

IAME2013 organizers met at on the 13 June 2012 at the facilities of University of Genoa in Imperia, few kilometres away from the French-Italian border. The meeting was mainly devoted to finalize the scientific process for IAME conference.



Laurent Fédi (Euromed Management), Francesco Parola (university of Naples Parthenope), Claudio Ferrari (University of Genoa) and Pierre Cariou (Euromed Management) in Imperia (Italy)

FEBRUARY 2012

The IAME 2013 organizing team gathered in Marseille on February 9, 2012. Professors Claudio Ferrari (University of Genoa), Francesco Parola (University of Naples Parthenope), and Elisabeth Gouvelal (IFSTTAR) met with the local organizing committee composed of Pierre Cariou, Laurent Fédi, Marie Cazade, Catherine Delon and Anya Penney (Euromed Management). One of the objectives of the meeting was to agree on the future conference location. The conference will take place at "Le Palais du Pharo" in Marseille. This imperial residence was built by Prince-President Louis-Napoleon in 1852. Today the site includes ceremonial rooms, a 1200 m2 exhibition hall, a 500 m2 restaurant and a 900-seat auditorium which can be adapted to accommodate conferences or seminars.

A view from Palais du Pharo on Marseille Old Port



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The International Association of Maritime Economists (IAME)

The International Association of Maritime Economists (IAME) is an international forum for the exchange of research and information among those interested in maritime and maritime-related issues. Membership is drawn from all continents and representation includes academics, industry and government. Members have the opportunity to interact with international colleagues by attending the annual IAME conferences (which are hosted by different institutions each year) and other conferences endorsed by IAME. It is particularly valuable for young researchers and students as it provides the opportunity to interact with more senior and experienced researchers and practitioners.

Euromed Management, Marseille Business School (France)

Euromed Management is a leading European business school with more than 6,000 students and 80 permanent Professors on the campuses of Marseille, Toulon, Marrakech, Algiers, Shanghai and Beijing. Euromed Management's strategic plan has identified maritime-related research and educational programs as one of the six priorities of the school for the next five years. Euromed Management offers 3 programs on maritime economics and logistics: a M.Sc. program since 1958, a specialized executive M.S program in cooperation with CMA-CGM and the Marseille Merchant Marine Academy since 2000 and a Maritime Executive MBA since 2009.

IFSTTAR, French institute of science and technology for transport, development and networks (France)

IFSTTAR was created on January 1, 2011 as the result of a merger between INRETS (Institut national de recherche sur les transports et leur sécurité) and the LCPC (Laboratoire Central des Ponts et Chaussées). IFSTTAR is a state financed scientific and technological establishment run under the joint supervision of the French Ministry of Ecology, Sustainable Development, Transport and Housing and of the French Ministry of Higher Education and Research. In 2011, IFSTTAR had 1268 staff members working for 25 research units that contributed to 74 patents and 350 international publications. The research unit SPLOTT specializes in production systems, logistics transport organization and disciplines

such as economics, planning, geography, sociology and ergonomics. Its objective is to understand the interactions between production systems, logistics and transport in different sectors and for different modes. SPLOTT covers the following themes: transport activities, freight transport and geographical areas including metropolitan and major maritime gateways, as well as transport practices and policy evaluations.

University of Genoa, Department of Economics (Italy)

The Department of Economics at the University of Genoa hosts a team of researchers in transportation. Education and research are mainly focused on maritime and logistics. The University delivers a M.Sc. program, a Ph.D. program and various short term courses. The Department is part of the Transportnet network. In recent years the Department has been involved in many academic research programs and consultancy studies on the transport sector commissioned by organizations such as the European Commission, the Association of Caribbean States, the Genoa Port Authority, and several private companies and government departments in Italy. The Department has the experience of (co-) organizing conferences including the WCTR "Special Interest Group Maritime transport and ports" (SIG-2) conference in 2000, and the annual conference of the Italian Association of Transport Economists in 2004.

University of Naples Parthenope, Department of Business Studies (Italy)

The Department of Business Studies at the University of Naples Parthenope offers a qualified team composed of professors and researchers with an extensive background in management, accounting and economic disciplines. The University, which originates from the ancient "Naval Institute" established through Royal Decree in 1920, is characterized by a long tradition in maritime transport and logistics both at a national and at a regional level. Profoundly embedded in the context of Italian shipowners, the Parthenope University has close relationships with the industry and territory, in particular with Mediterranean Shipping Company, D'Amato, Grimaldi and Terminal Napoli S.p.a. (passenger facility). It also has experience in organizing national and international conferences.



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Cost and time models for road haulage and intermodal transport using Short Sea Shipping in the North Sea Region

Alba Martínez-López¹
amartinezl@udc.es

Jacob Kronbak¹
jkr@sam.sdu.dk

Liping Jiang¹
lji@sam.sdu.dk

¹Unit for Maritime Research, Department of Environmental and Business Economics
Niels Bohrs Vej 9, DK-6700 Esbjerg, Denmark
Southern Denmark University

Abstract

This paper is framed in the context of the EU Interreg IVB North Sea Region project *Food Port*. In line with this project, this paper aims to define mathematically cost and time models able to provide realistic information about the performances of road haulage and of intermodal chains using Short Sea Shipping (SSS) in the North Sea Region (NSR). The models integrate the necessary variables to establish the impact of different fleets and SSS features on the competitiveness of intermodal chains for the movement of food related goods. The models were applied to evaluate the opportunities for the success of intermodal chains using the Rosyth-Zeebrugge route. The results obtained validate the utility of the models and they suggest possible changes to the current operation of this SSS service in order to increase the marked potential possibilities for the intermodal chains through Rosyth-Zeebrugge.

Keywords: Transportation Cost, Short Sea Shipping Transport, Ro-Ro Transport, Container Feeder Transport, Intermodal transport.

1. Introduction

In 2011, the European Commission published a new White Paper on transport, *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system* (Commission of the European Communities, 2011), which will lead European transport policy in the coming years. This policy mainly addresses a reduction of the transport sectors use of fossil combustibles, reducing atmospheric emissions (60% in 2050), and

alleviating congestion on European roads by promoting the principle that users of transport infrastructure must pay for the cost of it. The absolute predominance of road use compared to all other transport alternatives in Europe had already been identified as a relevant problem in the first European White Paper on transport of 1992 (Commission of the European Communities, 1992). Since then, first short sea shipping (SSS) and then Motorways of the Sea (MoS) concept, which linked European ports with high frequency and efficiency, were proposed as the most attractive solutions for intra-European transport, due to the low energy consumption per tonne transported. Thus, the integration of these new concepts of maritime transport in intermodal chains (road or railroad combined with maritime transport) offered possible alternatives for 'door to door' transport. As a result, the promotion of SSS has become a permanent objective of European transport policy from the 1990s to today. Since then, numerous studies and projects have been financed by the European Union (EU) and by country members with the intention of solving the weak points of intermodality, especially by boosting those maritime routes with the greatest possibility of success in articulating intermodal routes against unimodal road use. Hence, remarkable efforts have been made to identify the most promising potential corridors in which to establish short sea shipping services: in 2003, as a consequence of the Van Miert Report, the European Commission reviewed the extension of TEN-T (the Trans-European Transport Network) pointing to the development of the MoS as a priority project (this should be finished before 2020). On this occasion, four corridors were again highlighted, one of them was the Occidental European corridor included the articulation of the North Sea region with the rest of the countries of Atlantic Europe. In addition, in recent years, to improve the competitiveness of maritime transport, the EU has tried to eliminate the traditional protectionism towards maritime transport through different regulations, the most recent of which, Council Regulation (EC) No 1419/2006 (Council of the European Union, 2006), came into force in October 2008.

2. The problems and the aim

Despite all the efforts made by European Administrations, it is commonly accepted that the current development of SSS has not been as successful as expected (EC, 2002). The reasons are numerous but two arguments relating to the activity of intermodal transport must be noted: the low frequency, slow speeds of the service (Paixao and Marlow, 2001; Musso and Marchese, 2002) and lacks of efficiency of freight transitions between transportation modes (Chlomoudis and Pallis, 2002). Additionally, many of the studies that had analysed modal choice concluded that this depends highly on the characteristics of the load (value added of the freight, size of the cargo unit and the type of the loader company) and the influence of the locality of the origins, destinations and ports (Garcia-Menendez and Feo-Valero, 2009). Therefore, each intermodal route is characterized by a combination of operative features, customer requirements and geographic characteristics, which provide a complex transport service with a relative competitiveness unimodal transport (Baird A., 2004). On the other

hand, the imbalance in the internalization of external costs between SSS and the road has led to the EU transferring the responsibility for the success of intermodal transport to private initiatives (Gese and Baird, 2010; Romana et al, 2010). Hence, those shipping companies which are willing to deal with SSS services have to cope with the new problem of the absence of protectionism in the sector, assume a position of initial disadvantage with regard to road transport, and take decisions about the operative and technical characteristics of the fleet (Woxenius, 2010), all of which influence the features of the intermodal service. This reality can be seen in the evolution of some SSS routes in the last years. In the case of Rosyth-Zeebrugge (between Scotland and Belgium), for instance, from 2002 to date the route has been covered by many different kinds of fleets (two fast ferries, one fast ferry, one small fast ferry, one ferry, two Ro-Ro vessels and one Ro-Ro vessel) which offered different conditions of service (a daily service, four calls per week, and three calls per week). Despite this, the competitiveness studies for multimodal transport through SSS have seldom considered as variable elements: the features of the intermodal transport network and the technical features of the vessels simultaneously. Thus, the aim is usually the selection or analysis of the most suitable route for a fixed fleet (Koi Yu Ng A. 2009, Perez-Mesa et al.,2010) or the technical adaptation of vessels to a rigid maritime route (Ametller,2007). This has already been studied as a combined problem by other authors (Hsu and Hsieh, 2007; Martínez de Osés et al., 2011) but without taking into account intermodal networks or different kinds of vessels, respectively. In this context, the EU project Food Port (INTERREG IV B-North Sea Region Programme) aims to define efficient corridors for the transport of food products among the countries of the North Sea Region (NSR). This work attempts to provide cost and time models for unimodal and intermodal transport in order to evaluate their relative competitiveness in NSR. Due to the significant effects on the route competitiveness of the technical and operative conditions of the fleet, the geographical locality of the routes and features of the cargo unit, all these aspects were first introduced in the formulation as variables. Thus, the models are not only useful to quickly evaluate the consequences of technical or operative modifications to the fleet on the competitiveness of the intermodal chains but also in understanding the impact on their competitiveness when there exists a change in the demand or in the configuration of the initial intermodal transport network. Once the method and models have been introduced, in order to enable understanding of their performance, models are applied to a real case of intermodal transport in the NSR. This is carried out through an analysis of the Rosyth-Zeebrugge maritime route, by considering both the current service and possible service alternatives. Finally, obtained findings and future research lines are discussed.

3. The method

Although the selection of transport mode by decision-makers is dependent on many factors (Culligane and Toy, 2000; Garcia-Menendez and Feo-Valero, 2009), two of these are core – the time and the cost – although with different relative importance according to, among other

aspects, the nature of the load (De Jong, 2000; Bergantino and Bolis, 2004). However, the analysis of these variables in the choice of transport modes requires that the possible 'door to door' transport networks for both the unimodal (road) and the intermodal (Road/SSS/Road) cases must firstly be defined (Paixao et al, 2010; Romana et al, 2010). In order to provide a realistic comparison, the same volume per cargo unit, the same frequency needs and the same number of nodes was assumed for the unimodal transport (road haulage) and for the intermodal transport. A 'many to many' transport model (Daganzo, 2005) was adopted as a transport network (see figure1), where the network nodes were the origins (z) and destinations (d) of the routes and the hubs were the consolidation terminals, in this case, the loading port (m) and the unloading port (k) or vice-versa. Each maritime route (DM) along with pre- and post-haulages by road (capillary hauls: DR_{zm}^b DR_{kd}^b) generated different intermodal transport routes, the results of which in terms of the time and cost were compared with the alternative road haulage (DR_{zd}^a) for every pair of nodes. In order to simplify the study, the number of nodes considered was limited to three for each coast and the relative probability of receiving or delivering a cargo unit (X_z, X_d) responded to a population criteria (Koi Yu Ng, 2009) due to the kind of the cargo considered in this case, namely food (a perishable load).

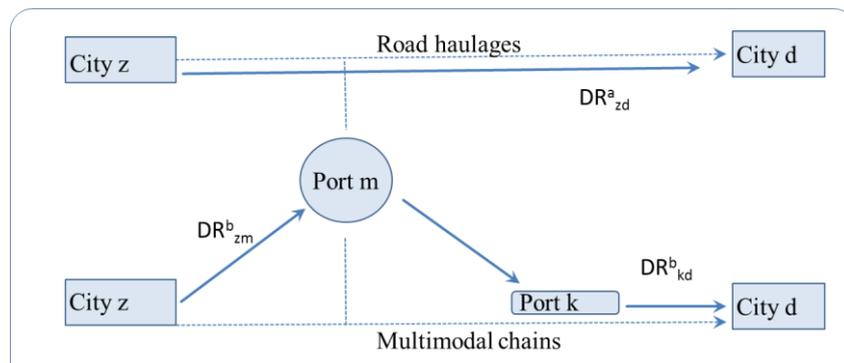


Figure 1-Transport networks

Most studies on the competitiveness of SSS suggest from a qualitative point of view that Ro-Ro vessels are the most suitable for SSS traffic (Paixao and Marlow, 2002; Woxenius, 2010; among others). However, some comparative studies based on quantitative methods indicate that container vessels can be more competitive (Mbiydzennyuy et al, 2010) and able to articulate more competitive intermodal routes than road haulage on certain routes (Koi Yu Ng, 2009). Indeed, in the North Sea Region, SSS services are provided by feeder container vessels (e.g. the Unifeeder shipping company), Ro-Ro vessels and Ro-Pax vessels (e.g. the DFDS shipping company). Due to the impact on costs, it is also interesting to point out that the average age of the fleet is eight years from acquisition (2005); however, while most of the container vessels were purchased as new builds, the Ro-Ro and Ro-Pax vessels were often incorporated into the fleets from the second-hand market with an initial age of five years. Considering the above and intending to provide models able to cover all the possible alternatives in the NSR, three kinds of fleet, TB_q (TB_1 : feeder container vessels; TB_2 : Ro-Ro

vessels; TB₃: Ro-Pax vessels), and their respective cargo units, TEU and a 5-axle truck with an average cargo capacity of 12.5 t (P₁) and 24 t (P₂) respectively, were considered. Taking into account the high influence of loading strategies for Ro-Ro traffic on the competitiveness of the intermodal transport service (Morales-Fusco et al, 2012), the models assumed for all cases accompanied cargoes for trucks but without drivers (Paixao and Marlow, 2002) and the most unfavourable situation – first in, last out – for all cargo units. Thus, in order to permit the comparison of results in terms of costs, these were calculated in euros per transported tonne. In addition, other variables were incorporated in the models (see Table 1) to analyse their impact on the competitiveness and to consider additional criteria in relation to modal choice (such as the frequency or the service N_{trips}, or the necessary cargo volume per trip α). As most of the cost and time items in the models are related to the different technical features of the vessels, to simplify the evaluation of the different alternatives of fleets, all these characteristics were integrated simply through the gross tonnage (GT) and the service speed of the vessel (V_b). For this, Clarkson’s World Fleet Register database was used to obtain the necessary relations among the technical features through regressions.

Table 1: Main variables of the models

GT	Gross Tonnage	DM	Maritime route (Km)	α	Utilization ratio of vessel (%)	δ	Profit of shipping company (%)
V _b	Speed of vessels (Kn)	N _B	Number of vessels	E _e	Purchase age of vessels	N _{trips}	Number of stoppages/year

4. The times model

Times were measured in all cases as hours per cargo unit and trip (‘door to door’). The time of the intermodal transport (T_{mt}) is the sum of the time invested in the trunk haul at sea (T_m) and the capillary hauls at land (T₁, T₂) of a ‘many to many’ transport model (see figure 1). For the calculation of the times consumption on all the road stretches – road haulage (TVU) and the capillary hauls – the following assumptions were made: continuous traffic and the application of European Directives relating to speed limiting (92/24/CE and 92/6/CE), maximum daily driving times and minimum driving rests (Regulation CE 561/2006), and a hypothetical ‘many to many’ transport model (see figure 1):

$$T_1 = \sum_{z=1}^3 (X_z \times [E \left[\frac{E \left(\frac{DR^{b_{zm}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{zm}}}{V_3}}{9} \right] \times 24 + \left[\left(\frac{E \left(\frac{DR^{b_{zm}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{zm}}}{V_3}}{9} \right) - E \left[\frac{E \left(\frac{DR^{b_{zm}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{zm}}}{V_3}}{9} \right] \right] \times 9]) \quad (1)$$

$$T_2 = \sum_{d=1}^3 (X_d \times [E \left[\frac{E \left(\frac{DR^{b_{kd}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{kd}}}{V_3}}{9} \right] \times 24 + \left[\left(\frac{E \left(\frac{DR^{b_{kd}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{kd}}}{V_3}}{9} \right) - E \left[\frac{E \left(\frac{DR^{b_{kd}}}{9 \times V_3} \right) \times 0.75 + \frac{DR^{b_{kd}}}{V_3}}{9} \right] \right] \times 9]) \quad (2)$$

In the expressions 1, 2 and 3 are step functions (Sandberg T. et al., 2012) where a maximum driving time of 9 hours per day and rests of 45 minutes every hour were considered.

$$TVU = \sum_{z=1}^3 \sum_{d=1}^3 (X_z \times X_d \times [E \left[\frac{E \left(\frac{DR_{zd}^a}{9 \times V_3} \right) \times 0.75 + \frac{DR_{zd}^a}{V_3}}{9} \right] \times 24 + \left[\left(\frac{E \left(\frac{DR_{zd}^a}{9 \times V_3} \right) \times 0.75 + \frac{DR_{zd}^a}{V_3}}{9} \right) - E \left[\frac{E \left(\frac{DR_{zd}^a}{9 \times V_3} \right) \times 0.75 + \frac{DR_{zd}^a}{V_3}}{9} \right] \right] \times 9]) \quad (3)$$

In the intermodal chains the time used on trunk haulage (maritime stretch) T_m integrates all the items shown in figure 2, and represents the time of one cargo unit from its delivery at Port A until its departure from Port B. The port operations time (T_p) is clearly highly dependent on the port, the cargo unit and the kind of vessel and includes the waiting time in port (T_w) (the internal transfer movements for the cargo units in port and the queuing times) and the loading time (T_l). The waiting time for Ro-Ro traffic implies the time necessary to organize the boarding of trucks and trailers (approximately one hour). For container traffic, assuming a semi-direct route for the containers in port (Taleb-Ibrahimi, 1989), this time involves the stay in the operation zone (half an hour), and the internal transfer process time (half an hour), namely the time invested in the reception process and the time for three transshipments: from the truck to the operation zone, from the operation zone to a truck platform which carries the container to the dock, and finally the transshipment between the dock and the vessel.

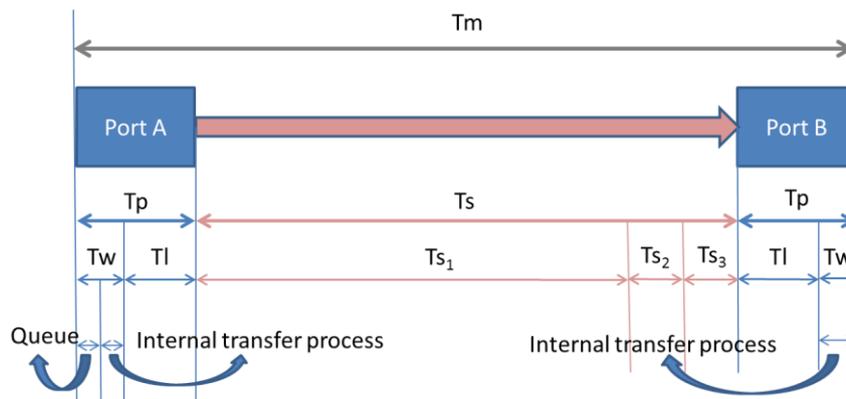


Figure 2- Times structure for the trunk haul of the intermodal transport network

The expressions for the loading time are shown in table 2 assuming that the loading operations in dock for containers are carried out with Portainer cranes (one crane per 37 meters of length between the perpendiculars of a vessel operating with an average crane speed $V_{2g}=27$ TEU/h). For Ro-Ro freight traffic (this also includes Ro-Pax vessels), it is necessary to take into account the particular norms for every port or stowage company, which normally prescribe a minimum number of drivers per number of trucks ($N \text{ drivers} = \text{trailers} \times \alpha / 19$) of a certain length (DC1,2) for the loading operations, and they normally provide an average speed for the loading operation per driver (ratio=8 trailers/(driver×hour)). The shipping time (T_s) is

made up of the sailing time (Ts_1) the port pilot time (Ts_2) and the tug service time (Ts_3) (see figure 2).

$$Ts_1 = DM / (Vb \times 1,85) \quad (4)$$

Table 2: Expressions for the loading times per kind of vessel

Feeder vessels(TB_1)	$Tl = \left(\frac{GT - 1909,8}{8,516} \right) \alpha \times \frac{2}{V2g \times E((0,0054GT + 81,342) / 37)}$
Ro-Ro vessels (TB_2)	$Tl = \alpha \times ((0,0045GT - 21,09)^{0,5} - 2,336) / (DC1,2 \times 0,0022) \times \frac{2}{(ratio \times Ndrivers)}$
Ro-Pax vessels (TB_2)	$Tl = 2 \times \frac{\alpha}{DC1,2 \times ratio \times Ndrivers} \times \left(\frac{GT - 503,21}{10,48} \right)$

The compulsory use of the port pilot and/or towing services is dependent on the port rules. These rules normally set up relationships between the technical features of the vessels (the length, GT, beam and the bow thrust of the vessels, the number of shaft lines, and even the kind of rudders) and the mandatory use of these port services. The use of the port pilot is normally enforced by National Rules according to the safety requirements for operation in ports, and the pilot's duties are normally dependent on the gross tonnage of the vessels. However, the towing service is often dependent on the features of ports and therefore the Port Authority is the entity responsible for defining the requirements for its use. The obligation to use the towing service is associated mainly with features of a vessel's capacity for manoeuvrability: the installation of the bow thruster and the number of shaft lines. Clearly, the possible combination of all these inputs in the vessels is very wide, but paying attention to the database of Clarkson's World Fleet Register and the current fleets which are operating in the NSR, we can assume that in all cases the Ro-Pax, Ro-Ro and container vessels have at least one bow thruster. It is also assumed that the feeder vessels will have only one shaft line while the Ro-Ro and Ro-Pax vessels will have two shaft lines (according to the typical machine room arrangement for these vessels). Therefore the relevance of times Ts_2 and Ts_3 depends on the features of the vessels and on the ports. Despite the fact that the formulation for every considered port and for every option of vessel is too large to be introduced in this work, two reference values can be considered: 0.75 h per use of one port pilot (in Zeebrugge) and an additional time of 0.25 h for the use of each tugboat.

5. Costs models

The relative importance of the different costs that comprise the internal cost structure of SSS is not totally clear according to the literature consulted. Polo (2000) concluded that the most important costs in international liner shipping in Spain are capital costs (approximately 33% of the total costs of shipping transport) and loading costs (25%). However, Paixao and Marlow (2002) maintained that 70% of the total costs in SSS are due to port charges (they

also asserted that the inefficiency of port operations has been become, in the main, responsible for the lack of competitiveness of SSS). On the other hand, Sauri (2006) obtained results quite similar to those of Polo (2000), so for him the most representative costs for SSS traffic are mainly related to capital costs and port operation costs. Grosso et al (2008) identified the most important costs in SSS as firstly fuel costs and then the depreciation costs of the assets. Nevertheless, they concluded that the inputs responsible for the great variation in the freight prices among the different shipping companies were the fuel price and the benefit margin applied by the company (regulated by the competitiveness of the market on a concrete maritime route). The significant increase of fuel prices in 2007 and 2008 with respect to previous years could partially motivate these results but obviously the fuel cost is highly dependent on the different maritime distances considered for the different studies. Additionally, Grosso et al (2008) pointed out the independence of shipping costs and the final prices offered to the market (even over similar distances and with similar demands); among other factors, the utilization ratio of the vessels and the shipments should be noted. The Realise project (2004) concluded that the most important costs were firstly the depreciation of the vessels and then the fuel costs. However, except in a very few cases, where cost functions are developed considering the features of the fleets and of the service (Ametller, 2007; Sauri and Spunch, 2009), cost estimations tend to be based on generalized cost models applied to different maritime distances and relate to only one kind of vessel (Koi Yu Ng, 2009). These models are often developed using market information or interviews (Grosso et al, 2008) of a particular SSS service. This limits the possibility of comparing the performance of other kinds of fleet (number of vessels, kind of ships) or SSS services (frequency). The utilization of general cost models for intermodal transport, understood as a combination of rail and road, is especially typical of the analysis of competitiveness against road haulage (Janic, 2007; Sandberg Hanssen et al, 2012). Nevertheless, as previously stated, intermodal transport using SSS is highly conditioned by the features of the fleet, which determine the service conditions. On the other hand, many authors (Sauri, 2006; Perez-Mesa et al, 2010; Morales-Fusco et al, 2012) include in their analyses the concept of inventory costs, i.e. the costs associated with the maintenance of the cargo unit during the waiting time of the cargo units in port for the modal shift and the time associated with the trip by ship. The importance of inventory costs have also been mentioned by Paixao and Marlow (2002) who indicated the relevant impact of the average utilization rate of the vessels on the freight cost. In the following expressions, the cost models for road haulage (CU) and for the land stretch (CMU₁) of intermodal transport (CMU) made up of capillary hauls (CMU_{1,1}; CM_{1,2}) in the intermodal transport are shown, considering the addition of inventory costs (CM_{1,3}) and the profit of the transport company (μ) in the total cost of all land stretches (CU₁). Road transport costs are calculated considering a unitary cost per kilometre (C_{4,q}), which integrates the different cost items (Deliverable 5, Recordit Project, 2001; Koi Yu Ng, 2009; Perez-Mesa et al, 2010) and a unitary cost per time (β_1) for the inventory cost (CU₂). In addition, the weight of the cargo units (P_p) is considered for all possibilities P=1,2 (TEUs and trucks) as the results are given in euros per tonne.

$$CU = CU_1 \times (1 + \mu) + CU_2 \quad (5)$$

$$CU_1 = \left(\frac{C_{4,q}}{P_q}\right) \times \left(\sum_{z=1}^3 \sum_{d=1}^3 (X_z \times X_d \times DR_{zd}^a)\right) \quad \forall p \in P \quad (6)$$

$$CU_2 = \beta_1 \times \frac{TVU}{P_p} \quad \forall p \in P \quad (7)$$

$$CMU = CMU_1 + CMU_2 \quad (8)$$

$$CMU_1 = CMU_{1,1} + CMU_{1,2} + CMU_{1,3} \quad (9)$$

$$CMU_{1,1} = \left(\frac{C_{4,q}}{P_q}\right) \times \left(\sum_{z=1}^3 (X_z \times DR_{zm}^b)\right) \quad \forall p \in P \quad (10)$$

$$CMU_{1,2} = \left(\frac{C_{4,q}}{P_q}\right) \times \left(\sum_{d=1}^3 (X_d \times DR_{kd}^b)\right) \quad \forall p \in P \quad (11)$$

$$CMU_{1,3} = \beta_1 \times \frac{(T_1 + T_2)}{P_p} \quad \forall p \in P \quad (12)$$

The development of the cost model for trunk haul (CMU_2 maritime stretch) in the intermodal transport model was carried out by calculating the break point ($CM_{2,1}$ accounting criterion) for an SSS service integrating all the possible variables and afterwards the shipping company's profit (δ); the inventory costs ($CMU_{2,2}$) were also introduced.

$$CMU_2 = (CMU_{2,1}) \times (1 + \delta) + CMU_{2,2} \quad (13)$$

The inventory costs for the maritime stretch involve those costs generated by port operations ($(CM_{2,2})_a$) and by the shipping time ($(CM_{2,2})_b$):

$$M_{2,2} = (CM_{2,2})_a + (CM_{2,2})_b \quad (14)$$

$$(CM_{2,2})_a = \beta_2 \times \frac{Tp}{P_p} \quad \forall p \in P \quad (15)$$

$$(CM_{2,2})_b = \beta_3 \times \frac{Ts}{P_p} \quad \forall p \in P \quad (16)$$

5.1. The calculation of the break point for the maritime stretch ($CMU_{2,1}$)

From an accounting perspective, the costs calculated in this section correspond to the minimum required freight (see table 3), in other words the freight necessary to reach a zero gross margin for the shipping companies (break point). However, on this point structural costs of the company were not taken into account. Although in the literature there are multiple ways

to group different cost items associated with maritime transport (CT_c), these items are essentially the same in all studies focused uniquely on the yearly operating costs of the vessels for the shipping company (Hunt and Butman,1995; Watson, 2002; Xie et al, 2008; Sauri and Spunch,2009; Stopford,2009).

Table 3: Minimum required freight expressions (€/Tn) for different kinds of vessels

Feeder vessels (TB ₁)	$CMU_{2,1} = \left(\frac{1}{\alpha \times \left(\frac{GT - 1909,8}{8,516} \right) \times P_q \times Ntrip} \right) \times \sum_{c=1}^{12} (CT_c) \quad \forall p \in P$
Ro-Ro vessels (TB ₂)	$CMU_{2,1} = \left(\frac{1}{\alpha \times ((0,0045GT - 21,09)^{0,5} - 2,336) / (DC1,2 \times 0,0022) \times P_q \times Ntrip} \right) \times \sum_{c=1}^{12} (CT_c) \quad \forall p \in P$
Ro-Pax vessels (TB ₂)	$CMU_{2,1} = \left(\frac{1}{\alpha \times \left(\frac{GT - 503,21}{DC1,2 \times 10,48} \right) \times P_q \times Ntrip} \right) \times \sum_{c=1}^{12} (CT_c) \quad \forall p \in P$

These kinds of study try to determine costs corresponding to the break-even point or the minimum required freight (as in the case of this study) through the definition of the following yearly costs: capital costs as the integration of amortization costs (CT_1) and financing costs (CT_2). Continuing with the accounting approach, these last costs relate to the interest costs of the naval mortgage. Direct fixed costs involve insurance (CT_3), maintenance (CT_4) and crew costs (CT_5). Variable costs are combustible costs (CT_6) and operational port costs; the latter are very dependent on the port and on stowage companies and integrate ship duties (CT_7), load duties (CT_8), pilot duties (CT_9), towing duties (CT_{10}), mooring duties (CT_{11}) and loading costs (CT_{12}).

5.1.1. Capital costs

Attending to the classical accounting criterion, this item integrates the financial costs of the naval mortgage and the amortization of the ship value (Hunt and Butman, 1995; Wijnolst and Wergeland, 2009; among others), or of the chart payment according to the operating regime of the shipping company. In liner services, the shipping companies are often the ship owners (Sauri and Spunch, 2009) so this situation was assumed in this study. Additionally, hire costs and capital costs were considered equivalent due to their influence on the shipping account (Grosso et al, 2008). The inclusion of the amortization cost is usually limited by national rules (through the national general accounting plan). These limitations normally extend to the maximum time permitted for the annotation of the amortization of one vessel (A_2 around 20 years, $CT_1=0$ if $Ee > A_2$) and a maximum amortization ratio per year (around 10%). Although different amortization systems exist, it seems reasonable to take a straight-line system (Watson, 2002) as the majority of countries accept it. Thus:

$$CT_1 = \frac{CC - CC \times (100\% + R_1)}{A_2} \times NB \quad \text{if } Ee \leq A_2 \quad (17)$$

This amortization is related to the purchase cost of the ship (CC) and the residual value of the vessel (R_1) at the end of its amortization period, in other words, the percentage of the worth of the vessel regarding the current value of a new ship on the market at that moment. Clearly, this is highly dependent on the depreciation tendency of the vessel on the market and on the temporal situation of the second-hand market for freight shipping. Considering the features assumed for the NSR fleet (purchase year 2005 and building years 2000 and 2005) and the information provided by Clarkson's World Fleet Register and Clarkson Research Studies, the expressions shown in table 4 were obtained. Regarding the financial costs, probably one of the most commonly used naval loans is the mortgage-backed loan (Stopford, 2009) covering a percentage of the vessel's worth (R_4 , around 80%).

Table 4-Purchase cost (CC), depreciation ratio (R_1) and building cost (BC) per kind of vessels

Feeder vessels (TB ₁)	CC(€)	$(-4 \times 10^{-8} GT^2 + 0,0029 \times GT - 2,5447) \frac{10^6}{1,29}$
	R_1 (%)	$((-5 \times 10^{-11} \times GT^2 - 10^{-6} \times GT - 0,0249) \times A_2)$
	BC(€)	$(-4 \times 10^{-8} GT^2 + 0,0029 \times GT - 2,5447) \frac{10^6}{1,29}$
Ro-Ro vessels (TB ₂)	CC(€)	$\frac{(0,0019 \times GT + 0,463) \times 10^6}{1,29} \times (100\% + (-10^{-7} \times GT - 0,0067) \times 5)$
	R_1 (%)	$(5 \times 10^{-7} \times GT - 0,073) \times A_2$
	BC(€)	$\frac{(0,0019 \times GT + 0,463) \times 10^6}{1,29}$
Ro-Pax vessels (TB ₂)	CC(€)	$(0,0023 \times GT + 18,847) \times \frac{10^6}{1,29}$
	R_1 (%)	$(1 \times 10^{-6} \times GT - 0,0575) \times A_2$
	BC(€)	$(0,0023 \times GT + 18,847) \times \frac{10^6}{1,29}$

In order to simplify the calculation, an arithmetical capital amortization is assumed, and therefore the capital repayments are constant over the period of repayment (A_1 , normally eight years), while the interest payments (with an interest ratio R_2) decrease (see expression 18).

$$CT_2 = [(R_4 \times CC) - (E_e - 1) \times (CC \times R_4) / A_1] \times R_2 \times NB \quad \text{if } E_e \leq A_1 \quad (18)$$

5.1.2. Direct fixed costs

Naval insurance predominantly involves protection against damages to hull and machinery (H&M insurance) and insurance for third party claims: protection and indemnity (P&I). According to Stopford (2009) two thirds of the insurance tariff is due to H&M insurance and that is very dependent on the size of the vessel and its service time (A). The insurance history of the shipping company also has an effect on the insurance tariff. In order to estimate these costs (CT_3), data published by Wijnołst and Wergeland (2009) were considered for different kinds and size of vessel (see table 5). The maintenance expenses (CT_4) primarily involve the

stores, spares and periodic repairs/surveys demanded by the Flag Authorities and by the Classification Society (to keep the class stay). These costs are mainly related to the utilization, age and size of vessels (Kavussanos et al, 2004).

$$CT_4 = \left(\frac{1,20A^2 + 25,10A - 194,24}{100} + 1 \right) \times NB \times 0,82 / 100 \times BC \quad (19)$$

In order to simplify the expression of the maintenance costs (see expression 19) and to include the size of the vessels, we generalized the approach of Sauri and Spunch (2009) for old vessels (E_e) and for all kinds of vessel. We also considered the increase over the service time of the vessels from the time of their construction (A , eight years for feeder vessels and thirteen for other vessels in the NSR), according to Hunt and Butman (1995).

Table 5: Insurance costs (CT_3) and personnel costs (CT_5)

Feeder vessels (TB_1)	CT ₃ (€)	$NB \times (0,0134GT + 52,434) \times \frac{1000}{1,29}$
	CT ₅ (€)	$\left(\frac{53}{100} \times C_3^a + \frac{47}{100} \times C_3^b \right) \times NB \times (5 \times 10^{-4}GT + 14,981)$
Ro-Ro vessels (TB_2)	CT ₃ (€)	$NB \times (0,0153GT + 76,28) \times \frac{1000}{1,29}$
	CT ₅ (€)	$\left(\frac{44}{100} \times C_3^a + \frac{56}{100} \times C_3^b \right) \times NB \times (1 \times 10^{-3}GT + 8,9461)$
Ro-Pax vessels (TB_2)	CT ₃ (€)	$NB \times (0,0228GT + 455,48) \times \frac{1000}{1,29}$
	CT ₅ (€)	$\left(\frac{35}{100} \times C_3^a + \frac{65}{100} \times C_3^b \right) \times NB \times (1,5 \times 10^{-3}GT + 3,4165)$

To define the personnel costs (CT_5 , see table 5), it is first necessary to define the number of persons in the crew (NTR). The relationship between the vessel size and its crew is not direct; in fact it is more dependent on the building year (Stopford, 2009) and on the kind of machine room (unmanned or not). This discrepancy regarding the crew and the cargo capacity for container vessels was also noted by Wijnolst and Wergeland (2009). Despite this, in order to have a reference point, the crews were estimated from the information provided by Clarkson's database. Staff costs usually include the salary costs considering the staff rotation costs (rotation index=0.33). In addition to the costs of the salaries (Wijnolst and Wergeland, 2009) for the officers (C_3^a) and ratings (C_3^b), the crew distribution between them was estimated from the information provided by Wijnolst and Wergeland (2009) for Ro-Ro and container vessels, and by Sauri and Spunch (2009) for Ro-Pax vessels.

5.1.3. Variable costs

Authors such as Grosso et al (2008) and the results obtained in the Realise Project (2004) show the relevance of combustible costs (CT_6) for the operating accounts of SSS traffic. Combustible costs are primarily related to the operation of the main engines, and therefore are

dependent on the propulsion power installed (PB) and on the number of engines (NMP_a, one for feeder vessels and two for other ships). These parameters predominately determine the specific consumption of the propulsion plant (DT₁, see expression 20 obtained from the data published by Baird N., 1999). With the specific consumption, the unitary cost of combustibles (C₃^c), the combustible density (DT₂) and the time invested in the shipping (Ts₁), it is possible to calculate the yearly combustible costs (see expression 21). Additionally, the propulsion power was estimated through the adaptation of the classical Mau's expression (1969).

$$DT_1(\text{gr} / \text{HP h}) = 4 \times 10^{-8} \times (PB / NMP_a)^2 - 0.0031 \times PB / NMP_a + 179.69 \quad (20)$$

$$CT_6 = PB \times \frac{DT_1}{DT_2} \times C_3^c \times Ts_1 \times Ntrips \quad (21)$$

Table 6: Power estimation for the different kinds of vessels

Feeder vessels (TB ₁)	$PB(HP) = 0.0114 \times Vb^3 \times (1,4557 \times GT + 2070,8)^{(0.55)}$
Ro-Ro vessels (TB ₂)	$PB(HP) = 0.0114 \times Vb^3 \times (0,7358 \times GT + 3363,9)^{(0.55)}$
Ro-Pax vessels (TB ₂)	$PB(HP) = 0.0114 \times Vb^3 \times (0,5476 \times GT + 4368,1)^{(0.55)}$

The port costs integrate all derived costs from the utilization of the ports. Therefore, these are highly dependent on the conditions of the ports studied; some offer duty bonuses according to the number of stops of the vessels per year (Bremerhaven), or the environmental conditions of the vessels (Bremerhaven, Zeebrugge, and Gothenburg). Despite the fact that not all duties are applicable for all ports and vessels, the following expressions try to provide a generalized approach to dependences between the port duties in the NSR and vessel features. C_{2,p}^a is the unitary cost per tonne for ship duty (CT₇) – this duty, on occasion, is also charged as a function of the time in port of the vessel. X represents the fixed tariff per trip (these values depend primarily on the GT range of the vessel) for pilot services (CT₉), for tug services (CT₁₀, in some ports, otherwise depending on the vessel length), and mooring services (CT₁₁). Finally, the costs of port load duties (CT₈) and loading operation (CT₁₂) are defined by the unitary cost per cargo unit (Y) (see table 7):

$$CT_7 = Ntrip \times GT \times 2 \times C_{2,p}^a \quad (22)$$

$$CT_9; CT_{10}; CT_{11} = X \times 2 \times Ntrip \quad (23)$$

Table 7: Generalized expressions for load duties in port (CT₈) and for loading operations (CT₁₂)

Feeder vessels (TB ₁)	$CT_8; CT_{12} = 2 \times Ntrip \times (\alpha \times (GT - 1909,8) / 8,516 \times Y)$
Ro-Ro vessels (TB ₂)	$CT_8; CT_{12} = 2 \times Ntrip \times (\alpha \times ((0,0045GT - 21,09)^{0.5} - 2,336) / (DC1,2 \times 0,0022) \times Y)$
Ro-Pax vessels (TB ₂)	$CT_8; CT_{12} = 2 \times Ntrip \times (\alpha \times \frac{GT - 503,21}{10,48 \times DC1,2} \times Y)$

6. Practical application to the NSR: the maritime route Rosyth-Zeebrugge

From the Food Port Project findings (Work Package 5: Market knowledge), two ports are highlighted due to their potential for food transportation in the NSR: Zeebrugge, with six possible different destinations identified as relevant (in England, Sweden, Norway and Scotland) and Bremerhaven with three relevant destinations in Denmark and Norway. Nevertheless, of all the possible maritime routes from Zeebrugge in the NSR, the Rosyth-Zeebrugge (DM=750 km of maritime distance) was selected as the base case due to the continuous changes in the SSS conditions provided by the operators on this route. Thus, through the analysis of the competitiveness of the possible intermodal chains against the unimodal road haulage, not only did we attempt to obtain realistic costs and times for the transport modes (ensuring the best possible performance of the models), but also to determine whether the current SSS is competitive and to know, under ideal conditions (sufficient demand), which option of SSS service (of those applied up to-date on this route) was the most appropriate in terms of competitiveness. The main food goods moved from Scotland are fish, whisky and retail (Food Port project) and their main destinations are Germany, France and the Benelux zone. Thus, one city (d) per zone was chosen as a node on the continental coast (see figure 1): Dusseldorf, Lille and Brussels (with population relative weights: $X_1=31\%$, $X_2=12\%$, and $X_3=58\%$, respectively). On the Scottish coast, the nodes (z) were selected by population criteria: Glasgow, Aberdeen and Edinburgh ($X_1=48\%$, $X_2=18\%$, and $X_3=34\%$). Thus, with the transport networks obtained, the average distance for road haulage is 1100 km (DR_{zd}^a), and for the capillary hauls in the intermodal transport 70.92km (DR_{zm}^b), and 163.61km (DR_{kd}^b). Currently one Ro-Ro vessel (GT=11,530t and VB=20kn) covers this route offering an SSS service with three departures per week ($N_{trips}=245$); this SSS service serves as the base case. However, previously this route was covered by two Ro-Ro vessels with four weekly departures (option 1), one large Ro-Ro vessel (option 2), and two fast Ro-Pax vessels offering a daily service (option 3). Additionally the option of covering the route with one container vessel (with the features of the fleet used by Koi Yu Ng, 2009) with the frequency of 2 calls per week was also considered (option 4). All these options for the SSS service were evaluated under ideal conditions (the maximum cargo capacity offered by every alternatives of SSS service will be always covered by the demand) and their characteristics are shown in the table 8. Additionally table 8 shows the competitiveness results for the intermodal transport articulated through all these four options and the base case. According to the results obtained for the base case, the transport price for one accompanied truck on this maritime stretch is 1,076.10€ (assuming all full trucks) or 1,348€ (all trucks were 80% loaded in weight), while the price for the road haulage alternative is €1,708.70 (1,100 km) for a refrigerated truck (24 t). These values are quite close to real observations, so it can be accepted that these models obtain realistic values to study the competitiveness of intermodal transport in the NSR. On the other hand, looking at table 8 we can confirm that the current SSS service is not able to offer competitive intermodal chains (with the assumptions established) against road haulage in

terms of time (2.17 h of difference). In addition, the advantage in terms of the cost (13.03€/t) is not sufficient to attract perishable loads away from road haulage as, considering the transport of fresh fish for example, one hour's delay would only be compensated at a rate of 10.30€/t (Sandberg-Hanssen et al. 2012). Taking into account the rest of the options on this maritime route, it can be concluded that only option 3 (the first strategy introduced in relation to this route) could offer a competitive alternative to road haulage. This is based on the difference in time (3.27 h of advantage) and of the cost saving (11.36€/t). Regarding option 4, this offers the most competitive intermodal route in terms of costs but it is important to bear in mind that in this option the evaluation was based on another cargo unit of lower weight: one refrigerated TEU (12.5 t).

Table 8: Competitiveness results for the unimodal and intermodal transport obtained with different SSS services for the route Rosyth-Zeebrugge

Features	Base Case	Option1	Option2	Option3	Option4
Gross Tonnage (GT)	11530	11530	12189	30285	4500
TBq (1= Feeder;2=Ro-Ro;3=RoPax)	2	2	2	3	1
Vessel Speed Vb (Kn)	20	20	17	27.1	18
Maritim distance DM(Km)	750	750	750	750	750
Number of vessels (Nb)	1	2	1	2	1
Number of trips(N_{trip})	245	326	214	524	165
Occupation ratio α (%)	0.8	0.8	0.8	0.8	0.8
Purchase age of vessels (Ee)	8	8	8	8	8
Profit of shipping company δ (%)	0.1	0.1	0.1	0.1	0.1
Results					
TIMES					
Unimodal transport (h)	27.96	27.96	27.96	27.96	27.96
Intermodal transport (h)	30.13	30.13	33.24	24.69	37.22
Time invested in land stretches(T1)	0.79	0.79	0.79	0.79	0.79
Time invested in land stretches (T2)	1.82	1.82	1.82	1.82	1.82
Port Times (h)	5.75	5.75	5.29	5.63	10.59
Shipping time (h)	21.77	21.77	25.35	16.46	24.02
COSTS					
Unimodal transport (€/Tn)	71.20	71.20	71.20	71.20	136.7
Intermodal transport Zeebrugge(€/Tn)	58.17	62.51	52.85	59.84	56.28
Costs of the land stretches(€/Tn)	13.69	13.69	13.69	13.69	26.29
Maritime transport(€/Tn)	44.47	48.82	39.16	46.15	29.99
<i>Cost of the maritime transport (inventory)(€/Tn)</i>	1.84	1.84	2.03	1.50	4.58
<i>Costs of maritime transport in the break point (€/Tn)</i>	38.76	42.70	33.76	40.59	23.10
NECESSARY DEMAND AND FREQUENCY					
Yearly Cargo units (trailers/TEUS)	22,540	29,992	21,400	94,844	40,095
Maximum Yearly Tones	540,960	719,808	513,600	2,276,256	501,188
Frequency (weakly departures/direction)	3	4	2 and 3	6 and 7	2

Despite this advantage, this option leads to the intermodal transport is not feasible for the transportation of food due to the great difference in transport time between it and road haulage (9.26 h). Up to this point, previous analyses were undertaken under ideal conditions; in other words, they assumed that the demand and frequency required by the shippers coincided absolutely with those provided by the service. Nevertheless, significant differences between the maximum yearly Tones and frequency provided by the base case and the best option (option 3) necessitated a deeper analysis concerning the less demanding option (the base case). Hence, a demand reduction of 23.01% involves a significant increase in the cost per tonne of 22.39% but also a light decrease for the intermodal transport time (1.71%). This is mainly due to the time invested in port load operations, which is based on step functions ($N \text{ drivers} = \text{trailers} \times \alpha / 19$, see figure 3).

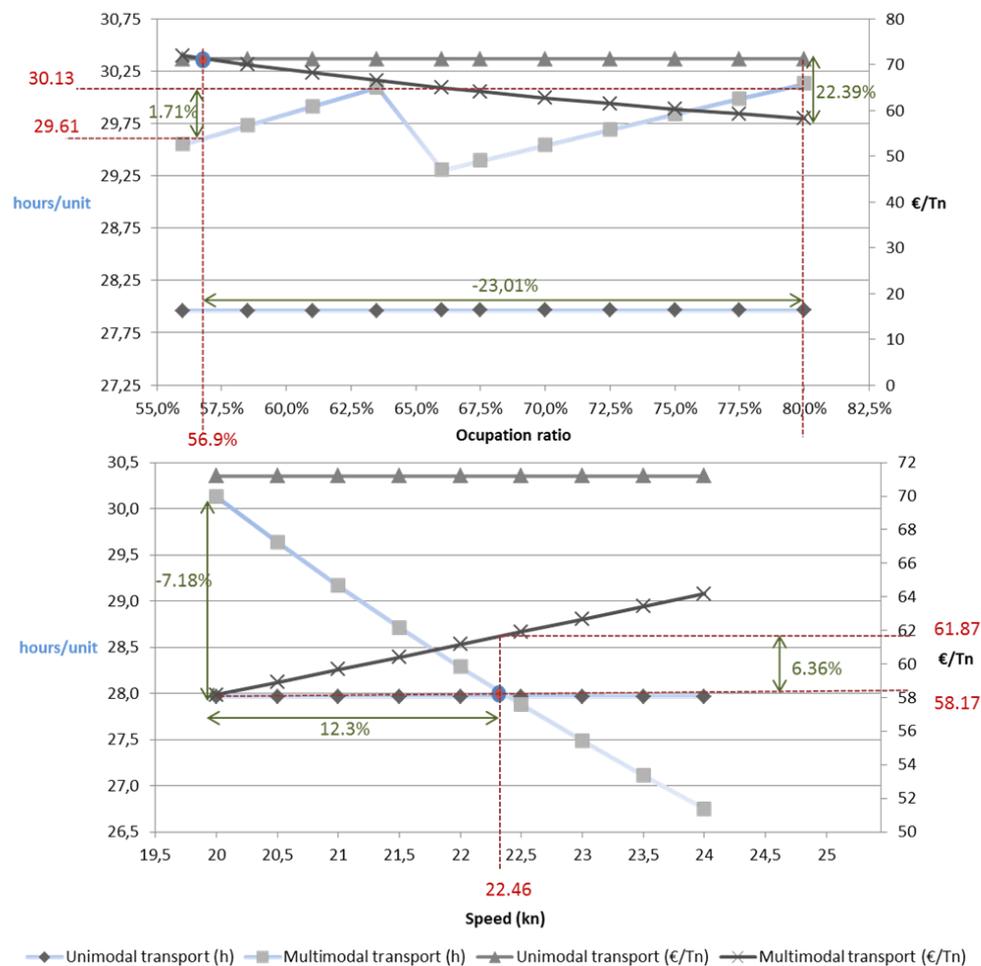


Figure 3-Competitiveness consequences of modifications of the occupation ratio and the speed of the vessel in the base case.

Thus, the time reduction for this motive would not be sufficient (29.61 h against 27.96 h for road haulage) to attract new loads. These results suggest that there are wide possibilities for the improvement of the operation and sizing of the fleet in this route. For example, through an

increase of 12.30% of the current speed of the vessel (see figure3) would lead to the same competitiveness in terms of the time for the intermodal transport as for the road haulage with a total time reduction for the first one of 7.18%. With this new situation, the intermodal cost would increase 6.36% and cost difference between both transport systems would be 9.33€/t being this favorable to the intermodal chain. Hence, this new operation could be interesting for the transport of perishable goods; nevertheless, this new strategy implies a higher frequency for the service and hence a higher yearly required demand from shippers (587,328t against 540,960t) to keep the aforementioned advantage in terms of costs.

7. Conclusions

Despite the great efforts made by the EU from the 1990s onwards, the success of intermodal transport through SSS has not been reached. The relative competitiveness of the road and intermodal transport is a consequence of the combination of numerous technical-operative variables of transport systems, cargo units and the localization of nodes and hubs within the transport network. For this reason the utilization of general expressions to predict the intermodal transport performance through SSS is not adequate. Thereby, this study which was developed in the Food Port project framework, aimed to determine detailed time and cost models for unimodal and intermodal transport. These models should be able to provide realistic information about competitiveness of these transport systems in the NSR for the transportation of perishable loads. It was thus necessary that, the models observed all the possible main variables in order to permit the analysis of different combinations of alternative transport. Consequently, to evaluate the relevant influence of SSS operation and the characteristics of their fleets regarding the intermodal transport performance, the models developed included the following variables: the kind of vessel and cargo unit, the GT of vessels and their utilization rate, the number of available vessels for one route, the profits applied by the company, the frequency of the SSS line, the speed of the vessels and the distances for every stretch of the transport modes. The transport network assumed to be operating was a 'many to many' model where the ports were identified as hubs and nodes as the extreme points of the lines (population criterion). With the intention of testing the correct performance of the models, these were applied to a particular case in the NSR: possible intermodal transport networks through the Rosyth-Zeebrugge maritime route. From this analysis, we can conclude that the models are not only useful to provide realistic information about the transport systems operation, but also to evaluate the influence of different SSS scenarios (fleets, services, operation, transport demand, etc) on the success of intermodal transport. Hence, in the case of the application of Rosyth-Zeebrugge, the results obtained from the analysis of different SSS possibilities for this maritime route indicated that the initial strategy carried out for its operation (the daily operation of two fast ferries) enabled the establishment of intermodal routes with the highest possibilities of success against the road haulage if the service demand was sufficient. Despite the fact that the current SSS service did not seem to provide competitive intermodal routes for perishable goods within the transport

networks assumed, there exist wide improvement's possibilities through the correct adaptation of the service operation and fleets. As suggested before, simple modifications to the speed of vessels and their frequency can create competitive intermodal chains, but with very close conditions to those of road haulage. Hence, to offer wider perspectives for the analysis of the scenarios carried out with these models, future studies should focus on the introduction of the externalities in the models for both transport systems, such as emission levels. This would allow, in line with the main aim of European White Paper on transport (2011), the evaluation not just of the consequences of an eventual modification of the modal split in terms of the time and costs for the transport systems, but also of the potential environmental impact on citizens.

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