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Sea-rail intermodality in the European Ro-Ro market: the case of Trieste Port

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Introduction

The sea-rail intermodality concept relates to development of a competitive transport service, using two different transport modes and based on cargo unitization, in alternative to unimodal road transport (Kapros and Panou, 2007). Cargo transhipment is performed in dedicated terminal, whose efficiency is essential for the good operation of the whole logistic chain.

Transport service providers, shipping lines, terminal operators and freight forwarders, in the negative phase of economic cycle, are facing several challenges in redesigning costs structure (prices, costs fuel, labor costs, etc.) and improving synchronization of different transport modes. Also seaports are becoming more than simply transit nodes, but they are evolving into important transhipment points within global supply chains.

The so-called “port regionalization” has occurred in many European countries, as a result of seaports expansion towards hinterland with the creation of satellite structures strongly connected. In some countries, including Italy, there was in many cases the creation of independent and unsuccessful intermodal terminal, called “interporti”, with poor or absent relations with seaports.

Creation of an efficient intermodal transport network is also an European priority, on which EU has dedicated feasibility studies, specific legislation and consistent financial funds. EU launched several projects to promote and improve intermodal transport system efficiency. Despite several efforts towards a closer integration among transport modes, this cooperation is still at an infant stage especially between sea and railway system (Ballis e Golias 2001).

The analysis of literature underlines that a variety of papers attempted to quantify intermodal terminal efficiency. As documented in existing research, variables concerning terminal infrastructures affects significantly efficiency and freight volume served. While some parameters are determined by context conditions, such as customs and border control, others are determined by terminal owners and port authorities.

Among these variables, handling equipment plays a dominant role since it determines terminal limits and productivity. Anyhow several research works concern sea-rail transport but they are mainly focused on container or automotive sector, even if trailer and semi-trailer market presents a significant and strong demand in European international trade. Moreover even if researchers appeared increasingly concerned about sea-rail issues, only few studies use questionnaires to terminal operators or potential users as analysis tool. Woxenius and Bergqvist (2011) studied the competitiveness of Gothenburg. Rodrigue and Notteboom (2010) analyzed differences between European and North America intermodal dynamics. Bergantino and Bolis (2008) used stated preferences analysis to understand the importance of Ro-Ro service attributes, compared to other land transport solutions. Baindur and Viegas (2012) estimated the potential demand for an alternative Ro-Ro based solution, using an agent based model for assessing modal share intermodality. Forte e Siviero (2014) investigated the capacity of Italian ports to compete in the Ro-Ro-Rail intermodal market, through a competitiveness evaluation model based on the principle components analysis (PCA), determining a performance index.

This paper aims at studying sea-rail intermodal transport in European Ro-Ro market assessing the efficiency of operative ports and their capacity to compete in this market. The analysis focused on a sample of 19 European ports, in which Ro-Ro-Rail (hereafter Ro-Ra) traffic is present. Through a combination of operators and port authorities interviews, this research has constructed a database of infrastructural and traffic data. The result is a performance index estimation, that ranks the relative competitiveness of each Ro-Ra port. It is also dedicated a specific focus on Trieste port case in order to learn from its success and to find critical factors for sea-rail implementation projects in the Italian context.

This paper is structured as follows. Section 2 describes basic concepts of sea-rail transport system and Section 3 explain estimation strategy. Section 4 presents and discusses results. Section 5 focus on Ro-Ra service in Trieste port. Section 6 concludes.

Basic concepts of Ro-Ra system

The European Commission, in 2002, has given the following definition of intermodal transport:

"Intermodal freight transport provides transport for consolidated loads such as containers, swap-bodies and semi-trailers by combining two or more modes".

The two major differences with respect to unimodal transport lie in the fact that freight is consolidated in a standard loading unit and that cargo movement by different transport modes happens without handling. These differences have shaped intermodality as a complex industry, that requires regularity, service network organization, fixed schedule and fixed freight. Moreover it is characterized by a large number of practitioners and operators. The logistics organization is set by third-party logistics operators (3PL) or Non Vessel Operating Common Carriers (NVOCC), who coordinate and oversee all transportation chain.

This paper analyses only the Ro-Ra transport characteristics, that is a sea-rail combined transport where trucks or trailer are transported by Ro-Ro vessels and train. Most of the journey takes place by sea or by rail, only initial and final legs are carried out by road.

Ro-Ra system offers an intermodal transport network that modally shift cargo from the highways to sea and rail for medium-long distances, but requires careful considerations on the best use of infrastructures. It can provide an economical and reliable transportation, especially for long distances[1] where it can reach economies of scale and fuel efficiencies. In this way, trucks does only the short haul pick up and the delivery to final destination.

For construction of co-modal European itineraries of the core network, defined by the European Commission (EC) as TEN-T policy, there is a considerable interest in the possibility of carrying out Ro-Ra services. This technique of combined sea-rail transport is almost completely absent in Italian ports, with the only exception of Trieste, where a sea-rail service is currently operative for rolling cargoes with port terminalization.

U.N. Ro-Ro, Ulusoy and Ekol Logistics operate from Turkey to Italy and they provides intermodal rail connections from Italy to North Europe. The road vehicles arrive on the quays and, instead of continuing by road, are loaded onto Ro-Ro ships and then on special trains specifically reduced for the sea-rail transport (also defined as "Rolling Motorway" – RoMo or "Rollende Landstrasse" - RoLa.).

These successful operations provide a complete door-to-door transport service and can offer a business model that can be applied to future intermodal solutions. The traffic is bound to increase, thanks also to the reductions in customs duties provided by the free port regime.

Another recent case of sea-rail logistics is the transport of new Fiat 500L, produced in Serbia and transported by Grimaldi Lines operator. Cars arrive by rail as far at the port of Bar, completing a journey of 450 kilometres. Grimaldi Lines offers a twice-weekly line for rolling cargoes between Bar, Salerno, Catania and various ports in the USA where the vehicles will be distributed. On imports side, motor car components travel from Italy to Bar, by ships, and then to the Fiat factory in Serbia, by train, for assembling (Forte and Siviero, 2014).

Concerning Italy, sea-rail transport could find a potential market in the longitudinal links along the Tyrrhenian and Adriatic lines.

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[1] The nature of semi-trailer suggests longer distances than container for profitability. The current container rail shuttle system is profitable below 100 km, while the break-even point for semi-trailers is estimated at 150 km (Woxenius, Bergqvist, 2011).

The transport of new motor vehicles, extensively carried out by Ro-Ro ships in the Mediterranean, might represent an interesting cargo typology for Ro-Ra services. Also the traffic between south-western Mediterranean region (North Africa, Sicily) and Eastern Europe (Germany, Poland), for example, may be considered for sea-rail solution. For such routes, the Sulphur Emission Control Areas (SECAs) limitations, already operating in the Baltic Sea, in the North Sea and in the English Channel, may provide a further incentive to use Ro-Ra transport.

Another interesting area for sea-rail development is Northern Europe. A case study on the port of Gothenburg has estimated that almost 100.000 semi-trailers were transported further than 150 km in the year 2006 and they can be transferred from road to rail, generating a potential for the Ro-Ra market segment (Woxenius, Bergqvist, 2011).

The actual lacking situation of Italian sea-rail services is mainly due to a poor supply by rail operators, first of all Trenitalia Cargo (RFI), and weaknesses of seaport infrastructure where, except in rare cases, dedicated intermodal terminals for sea-rail rolling cargo transhipment are not present. Currently in Italy the majority of semi-trailers shipped by rail are shunted in intermodal inland centers, not near the ports. In this context it is clear that the need of new rail operators is essential for an improvement in the railway sector and to make rail a more competitive alternative in inland services.

Hinterland transport of vehicles and unit loads that are “cross-docked” in ports is an old phenomenon, but business activity and policy making has intensified over the last ten years. Intermodal and unit load technology is evolving, while the image of road transport is even more undermined for environmental and quality reasons. In fact the negative image of road haulage imply that shippers increasingly demand intermodal solutions rather than all-road transport. Moreover political pressure is also increasing and the industry must respond at a satisfactory rate, particularly in view that potential aggressive regulation waits around the corner. Another factor that is becoming important is the emission cap. For example, in Sweden, they impede logistics nodes expansion unless the transport model is changed (Bergqvist and Woxenius, 2011).

The increase of sea-rail transport is important also from a seaport perspective. By investing in intermodal terminal and participating in the development of a network, a seaport can establish itself in inland regions. For this reason intermodal infrastructures may be considered a point of strength for seaports in the global competition.

Ro-Ra terminal, currently operating in Europe, are localized into three main areas: North European, North Adriatic and Mediterranean area.

The main terminal in North European area are Gothenburg, Rotterdam, Antwerp, Bremerhaven, Amburgo, Amsterdam, Zeebruge, Le Havre, Felixstowe and Southampton. German ports (Hamburg and Bremerhaven), with 200-250 trains per day[2], show best performances in terms of rail traffic managed. The main seaport in North Adriatic area are Trieste, Koper and Rjeka. The Mediterranean area can rely on the following seaports: Marseille, Barcelona, Valencia and Algeciras.

Concerning number of days to reach Europe from East countries, Northern Europe required on average 3-4 days of navigation more than Mediterranean and 4-5 days more than Northern Adriatic. Anyhow, port choices depend not only by travel time but on a balance between time, network connections and destination areas. Northern Adriatic and Mediterranean ports would be competitive on delivery time, but they suffers in some cases of lacking and inefficient land connection system not only for freight but also for drivers.

From infrastructural point of view, a typical Ro-Ra terminal consists of a wide range of installations, ranging from simple terminal, providing transfer between two modes of transport, to more extensive centers, providing a number of value-added services such as storage, empties depot, maintenance, repair, etc.

A typical sea-rail terminal includes the following elements:

1. area for trailer and semi-trailer storage, marshalling and inspection purposes;
2. transhipment tracks (also named loading tracks) for train loading/unloading operations;
3. loading and driving lanes for trucks and trailer.

In the simplest type of operation, truck and semi-trailer arriving on the transhipment line, are loaded on the railway wagon and remains there until train departure. This type of operation enables a direct transhipment between ship and train, without intermediate storage. The loading sequence is dictated by the ship arrivals at the terminal.

Port competitiveness in the Ro-Ra market

Vertical integration of shipping companies along supply chain has created multimodal operators, who offer a wide range of services to their customers. For these companies, port choice largely depends on efficiency and reliability of logistics services.

[2] Source: European Parliament 2015.

This choice criteria explains why service providers or shipping companies give greater value to terminal organization and, in many cases, they take on the direct ownership. This process, which first broaden in the container market, is rapidly spreading also in the rolling sector. Some examples are U.N. Ro-Ro, that owns the 60% of Riva Traiana Ferry Terminal at Trieste, P&O Ferries and NYK Ro-Ro, that own respectively the whole terminal in Rotterdam and Bremerhaven.

Considering the current Ro-Ro traffic situation, with an increase of 4,5% in rolling total volumes for European ports in 2014[3], it is highly probable that the inland penetration and quality of intermodal services will become increasingly relevant.

Therefore ports will try to obtain a competitive position as vital nodes in logistics chains and to catch as much traffic as possible to increase employment and local development (Siviero and Forte, 2014).

In order to assess the efficiency of European Ro-Ro existing terminal, this research considers a set of 19 ports, provided with a sea-rail terminal, and this a representative research sample. The study observed port equipped for this traffic in Belgium, Croatia, France, Germany, Italy, Netherlands, Spain, Sweden and United Kingdom. Concerning Ro-Ro terminal, the following have been considered: Algeciras, Antwerp, Barcelona, Bremerhaven, Felixstowe, Gothenburg, Hamburg, Killingholme, Koper, Le Havre, London, Marseille, Rotterdam, Southampton, Trieste, Valencia, Vlissingen and Zeebruge. The sample includes seaports with only one Ro-Ra terminal and others with several. According to data collected from Espo database, **Table 1** (see p.10) presents the annual Ro-Ro volumes moved in 2014, via each port selected.

To assessing the degree of European Ro-Ra sector competitiveness, this analysis selected several infrastructural variables considered crucial and utilized for estimating the Port Performance Index (PPI). The port competitiveness is considered with reference to the European context, selecting the few currently operating, and with availability of data variables. Data of Ro-Ra terminal belongs from terminal operators and port authorities interviews. The questionnaire contains two sections: the first is directed at acquiring data on company infrastructural endowment, the second consisted in traffic volumes and characteristics data.

The lack of official data and operators reluctance on share company information, do not permit the sample segmentation into terminal operators subcategory, therefore the present analysis focused on Ro-Ra port characteristics as a whole. Moreover the same reasons do not permit to consider data on rail traffic volumes. Therefore, database has been completed with other sources, such as statistics on Ro-Ro transport published by Eurostat, data published by Port Authorities and on terminal operators websites.

[3] Source: Espo data 2015

Table 1 - Ro-Ro volumes through seaports selected (year 2014)

Seaports	Country	Volume*
Algeciras	Spain	6,727
Antwerp	Belgium	14,355
Barcelona	Spain	9,793
Bremerhaven	Germany	8,213
Felixstowe	Uk	N.A.**
Gothenburg	Sweden	9,787
Hamburg	Germany	2,004
Killingholme	Uk	N.A. **
Koper	Slovenia	N.A.***
Le Havre	France	1,411
London	Uk	8,187
Marseille	France	6,449
Rijeka	Croatia	N.A. ***
Rotterdam	Netherlands	26,044
Southampton	Uk	N.A.**
Trieste	Italy	7,286
Valencia	Spain	9,438
Vlissingen	Netherlands	9,166
Zeebruge	Belgium	14,236

* to be multiplied by 1,000 tons (container excluded). ** values not available because is a private seaport. *** values not available because of the port Authority collection data system.

Source: author's elaborations on ESPO data 2014

The variables used for estimating the measure of a Ro-Ro terminal performance index are:

- **Ro-Ro terminal area**, that expresses port capacity to offer a storage area in the case of unaccompanied cargo. Unlike containers, trailers cannot be stored on the other, requiring for this reason large dedicated areas;
- **Ro-Ro docks (number)**, that expresses port capacity to offer mooring services. For loading and unloading rolling cargoes, Ro-Ro ships have to place rear and/or side ramps through which the trucks and trailers may get on and off. This variable express port specialization degree and its capacity for receiving Ro-Ro ships.
- **Ro-Ro Berths (length)**, that expresses port capacity to receive different Ro-Ro ships dimensions;
- **Rail tracks endowment (number)**, that expresses the capacity of rail access to maritime terminals. The European projects render very clearly the importance of land infrastructure and its connection with maritime leg. It is clearly evident that such variable represents an important element to consider;

- **Rail endowment (length)**, that is another measure of the capacity of rail access to maritime terminals;
- **Warehouse dimension**, that expresses port capacity to offer a covered storage area for advanced logistic services;
- **Tractors**, equipment for handling rolling cargo that are not self-propelled (trailers and semi-trailers), indicates port specialization for unaccompanied rolling cargo;
- **Crane handling equipment**, such equipment expresses the competitiveness in terms of handling capacity of unaccompanied rolling cargoes.

In order to measure European Ro-Ra ports performance, this analysis has calculated a composite indicator, known as PPI-RO-RA (Port Performance Index-Roll On Roll Off-Rail), which summarizes single indicators in relation to the above-mentioned variables. The eight variables were inferred for the period of analysis 2010-2014. It must be specified that the index does not refer to specific terminals, but to the European Ro-Ra seaports context.

To determine the indicator, the present analysis applied the Principle Components Analysis (PCA) technique. PCA is a descriptive statistical technique aimed at representing the data matrix of topic studied. It is useful to construct composite indicators, summarizing complex phenomena. The motivation for using PCA is that helps to obtain an aggregate representation from various port multidimensional data. Using PCA technique in this specific analysis, allows aggregation of various port performances data, with reference to selected technical variables.

The index of port competitiveness is obtained as follows:

$$PPI_i\text{-}RO\text{-}RA = \sum_{k=1}^{n} W_k X_{ik}$$

where:

PPI_i-RO-RA = represents the index of port competitiveness with reference to infrastructural endowment;

W_K = is the weight of the k-th indicator;

X_{ik} = is the standardized value of different measurements units for the k-th indicator of the i-th port.

Data and empirical findings

The PCA considers database of 19 European ports in which Ro-Ra transport activity is present. The database relate to the survey years 2010-2014. The analysis used different sources because of the scarcity of data availability. These are: operators interviews, statistics on Ro-Ro transport published by Eurostat, data published by Port Authorities and on terminal operators websites.

A very interesting analysis would be considering also rail market throughput related to the port but official European source does not report rail throughput data separated by ports. For this reason the analysis consider only total Ro-Ro throughput as a output variable. **Table 2**, **Table 3** and **Table 4** reports descriptive statistics of the above-mentioned variables and PCA findings.

Table 2 - Statistical descriptive PCA variables

Variables		Obs.	Obs. missing data	Obs. without missing data	Minimum	Maximum	Average	SD
Area (mq)	VAR1	19	7	12	100,000.0	1,700.000.0	666,469.6	497,491.1
Docks (ml)	VAR2	19	12	7	800.0	5,120.0	2,158.0	1,524.0
Docks (nr)	VAR3	19	7	12	4.0	16.0	7.5	4.1
Rail tracks (nr)	VAR4	19	8	11	2.0	18.0	6.5	4.5
Rail tracks (ml)	VAR5	19	12	7	250.0	7,500.0	2,292.9	2,475.5
Warehouse (mq)	VAR6	19	13	6	3,000.0	125,000.0	36,602.3	49,341.1
Tractors	VAR7	19	15	4	5.0	57.0	29.3	21.4
Cranes	VAR8	19	11	8	3.0	60.0	14.6	18.8

Source: author’s elaborations

Table 3 - Correlation matrix (Pearson)

Variables	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8
VAR1	1	-0.617	-0.041	0.490	-0.250	0.770	0.658	0.619
VAR2	-0.617	1	-0.535	-0.893		-0.859	1.000	-0.705
VAR3	-0.041	-0.535	1	0.345	-0.262	0.498	0.916	-0.326
VAR4	0.490	-0.893	0.345	1	0.614	0.486	-0.906	0.664
VAR5	-0.250		-0.262	0.614	1	-1.000	-0.869	0.932
VAR6	0.770	-0.859	0.498	0.486	-1.000	1	0.787	0.981
VAR7	0.658	1.000	0.916	-0.906	-0.869	0.787	1	-0.853
VAR8	0.619	-0.705	-0.326	0.664	0.932	0.981	-0.853	1

Source: author’s elaborations

Table 4 - Eigenvalues

	F1	F2	F3	F4	F5
Eigenvalue	4,157	3,566	1,310	0,814	0,403
Variability (%)	40,557	34,789	12,779	7,939	3,935
Accumulated %	40,557	75,346	88,125	96,065	100,000

Source: author's elaborations

The PCA findings show that the first principal component (F1) accounts for 40.5% of the total variance and was utilized to determine the weight of the variables which make up the PPI-RO-RA index applying equation with the following coefficients (factor loading):

$$\boldsymbol{PPI-RO-RA} = 0.42VAR1 - 0.94VAR2 - 0.05VAR3 + 0.94VAR4 + 0.53VAR5 \\ + + 0.44VAR6 - 0.81VAR7 + 1.01VAR8$$

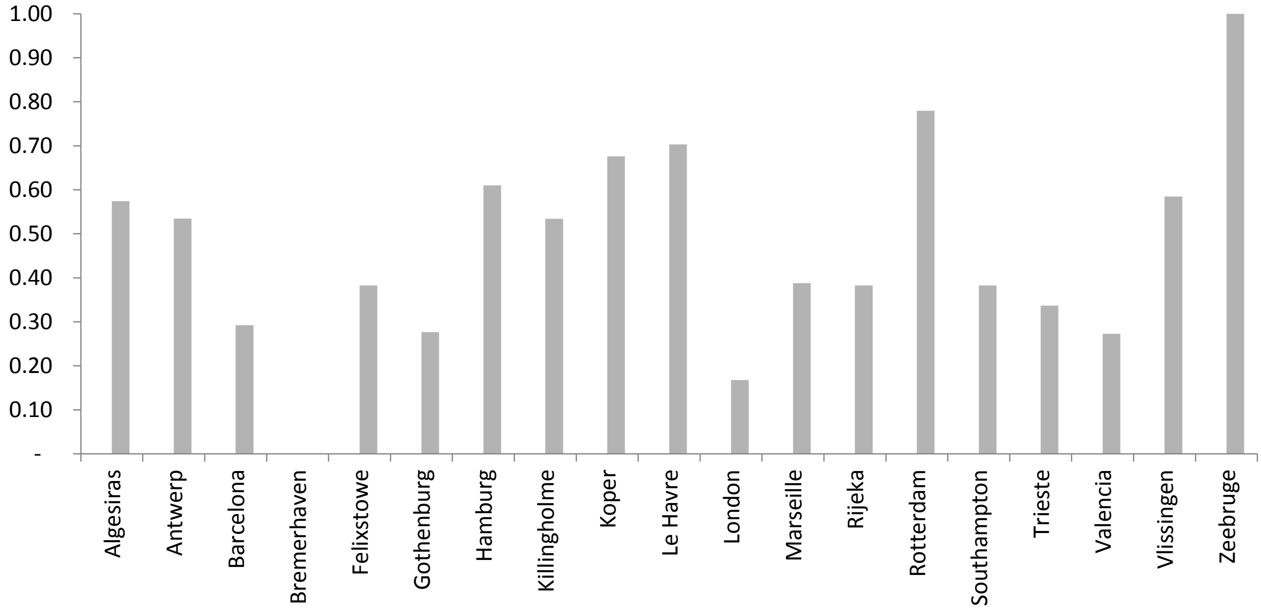
The greater weight in determining the competitiveness index is attributed to number of cranes, number and length of rail tracks. The number of berths, on the contrary, proves not to have any particular weight. **Table 5** reports port values normalized, **Figure 1** describe port classification, with regard to the composite PPI-RO-RA index.

Table 5 - Ro-Ra Port Performance Index normalized

Port Name	PPI RO-RO (norm 0-1)
Algeciras	0.49
Antwerp	0.44
Barcelona	0.15
Gothenburg	0.13
Hamburg	0.53
Killingholme	0.44
Koper	0.61
Le Havre	0.64
London	0.00
Marseille	0.26
Rotterdam	0.74
Trieste	0.20
Valencia	0.13
Vlissingen	0.50
Zeebruge	1.00
Average	*0.42*
SD	*0.27*

Source: author's elaborations

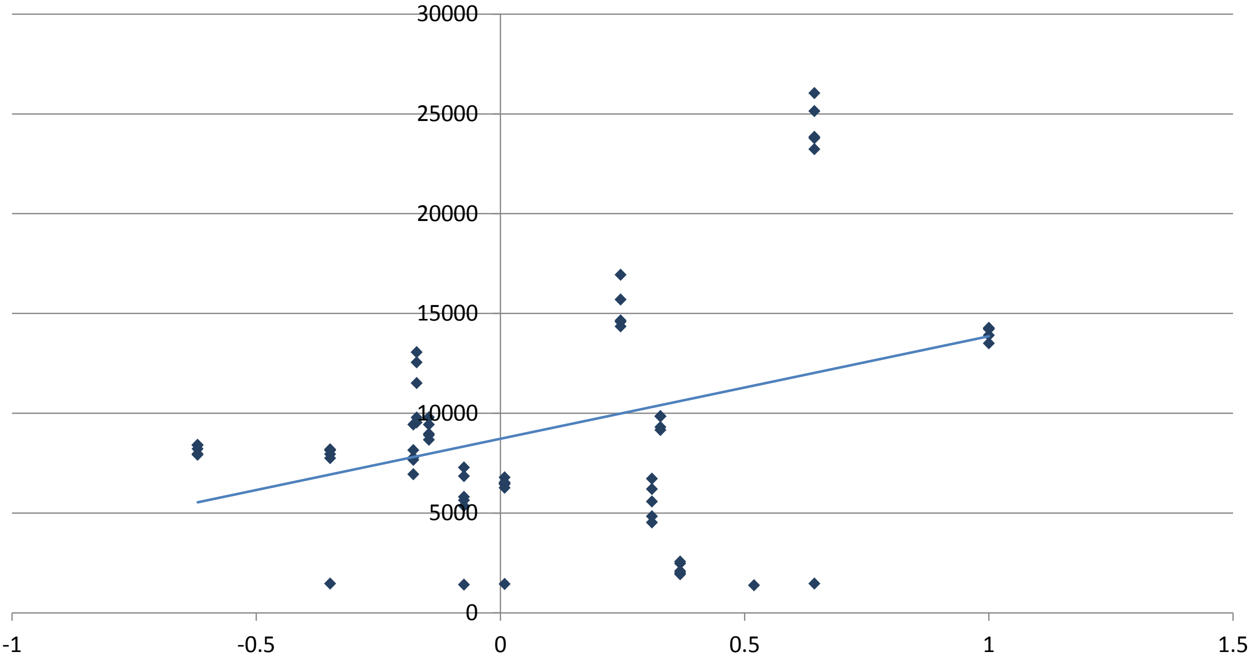
Figure 1 - Ro-Ra Port Performance Index classification



Source: author's elaborations

The OLS linear regression found a close relationship between PPI-RO-RA index and Ro-Ro total throughput pooled 2010-2014 (**Figure 2**). The robustness of linear relationship among variables is represented by R2 value, that is always positive. In this case R2 = 0,14, indicating that 14% of dependent variable variability is accounted by independent variables. For further details see **Table 6**.

Figure 2 - Performance Index linear regression



Source: author's elaborations

Table 6 - OLS Linear Regression elaborations

Source	SS	df	MS		Number of obs	68
Model	317,031,539	1	317,031,539		F (1.66)	10.99
Residual	1.9039E+09	66	28,846,939.5		Prob > F	0.0015
Total	2.2209E+09	67	33,148,202		R-squared	0.1427
					Adj R-squared	0.1298
					Root MSE	5,370.9
Throughput	**Coef.**	**Std. Err.**	**t**	**P > |t|**	**[95% Conf. Interval.]**	
ppi	5,155.121	1,555.025	3.32	0.001	2,050.413 - 8,259.829	
_cons	8,737.124	670.1937	13.04	0.000	7,399.039 - 10,075.21	

Source: author's elaborations

In conclusion, cranes endowments (VAR8), the number and length of rail links (VAR4 e VAR5) represent the most influential infrastructural factors for determining port competitiveness in the Ro-Ra market. The negative coefficient values registered for variables that express berths and tractors equipment (VAR2, VAR3 e VAR7) underlines that are not influencing in port performance. Concerning storage equipment (VAR1 e VAR6), they are important but not relevant. Indeed transhipment operations are usually very fast in Ro-Ra terminal.

According to this estimation, interesting ports for infrastructural endowments are Zeebruge, Rotterdam and Le Havre. This result confirm the competitiveness of Northern range ports, which are included in European TEN-T core network. An interesting new entry in this market is Koper, that registers a reasonable value for PPI indicator despite has entered this market only in 2015. Therefore it seems to have a great potential to increase this kind of intermodal traffic. On the other hand, London and Valencia, included in the core network, register a below-average indicator value.

This result confirms their purpose in other transport business. Also Trieste, the only Italian port in this sample, shows a low indicator value.

An illustration: Trieste Port

This Section gives a focus of Ro-Ra transport service between Turkey and central Europe through Trieste port, that farsighted Turkish entrepreneurs have gradually built up over the last decades. This is the only case in Italy and for this reason the author has thought it deserves a particular focus.

Turkey, an emerging economy as Europe trade partner, is a good example of sea-rail intermodal service implementation. As consequence of political changes in Mediterranean oriental area[4], this transport service is of great economic interest for Europe. Until at the end of the 80s, Turkish trade with Europe was limited to food and semi-finished goods. Nowadays, many Turkish companies have started producing manufactured goods for export to the European member states (at first to Germany, but now also to the Netherlands, Great Britain, Belgium, Italy and Portugal). Moreover many European firms established productive manufacturing bases in Turkey, creating an export flow of semi-finished goods.

The geopolitical situation until 1989, the year of Berlin Wall fall and of the opening for Eastern Europe countries to Western markets, did not allow the use of railways. For this reason, Turkish operators traveled by road through the Balkans. But in the Nineties the situation in former Yugoslavia made difficult the passage and forcing them to use intermodal sea-road transport, from Greece (Igoumenitsa) to Italian ports, and then by road until the final destination. However, road connections between Greece and Turkey was inadequate to this traffic. For this reason Turkish operators in 1994 developed this intermodal Ro-Ra transport solution.

Many aspects of this service, examined in next sub-sections, are innovative. To mention some peculiarities: the large geographical area it connects, the rapid market share evolution, the managing by a consortium of road transport companies at the origin, the use of combined sea-rail transport to reach the North European market, the air transfer of drivers, the rapid transformation to the structure of the companies.

The system currently has 10 different rail connections in Europe offered by three different rail operators. The port of Trieste has two dedicated intermodal terminal: the E.M.T. terminal and the Samer Seaports Terminal. The shortest rail service shuttle, about 18 km, serves the inland terminal Fernetti.

Turkish Ro-Ro traffic in the Trieste port

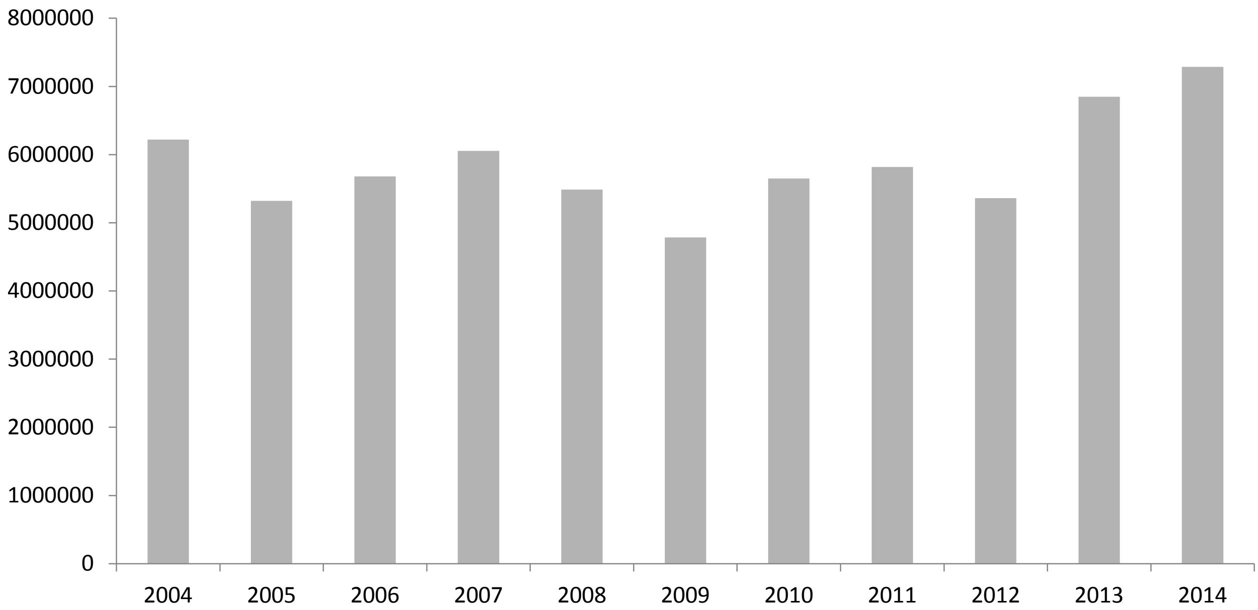
The port of Trieste has become a crucial point for trade between Europe and Turkey. Many aspect of this terminal are competitive: it is the northernmost Adriatic port and it is a “free port”[5], trailer going through Trieste do not need transit permission to travel through Italy.

[4] Turkey, Syria, Israel, Jordan, the Persian Gulf countries, and the oriental part of the Traceca area (Armenia, Georgia, Azerbaijan).

[5] A port or special section of a port where goods may be unloaded, stored, and shipped without payment of customs duties.

In 2014, trailer traffic by Ro-Ro vessels is 297.194 units (embarking or disembarking) for a total of 7.286.668 tons[6]. This traffic started in 1991 with 280.000 tons and has ever decreased until now[7] (**Figure 3**).

Figure 3 - Port of Trieste – Ro-Ro Traffic 2004-2014



Source: author's elaborations on Trieste Port Authority data

Ro-Ro terminal of Trieste is a classic example of how collaboration and network between small transport operators is important to reach exploitation of an efficient intermodal system. The Trieste-Istanbul route started in early 1990s, at the start of former Yugoslavia crisis. Road transit through Serbia and Croatia were hard and this situation encouraged the use of maritime transport, not previously considered. This solution became vital to avoid dangers of war zones. Many small Turkish transport firms joined in a consortium to manage their use of Trieste-Istanbul route with Ro-Ro ships.

This solution to bypass Balkans was so successful that a temporary measure became a transport revolution for trades between Turkey and Europe. The advantages are decrease in transport costs and less uncertainty of the time needed. The road transport implies numerous and often difficult custom controls along the route.

At this time 12 sailings a week connect Trieste to ports of Istanbul, Mersin, Pendik.

[6] Source: Assoporti data, 2014.

[7] Source: Trieste Port Authority.

Moreover Trieste offers 54 rail connections per week to Duisburg, Koln Eifeltor, Ludwigshafen, Frankfurt and Muenchen Riem (Germany), Bettembourg (Luxembourg), Ostrava (Czech Republic), Salzburg and Wels (Austria).

Moreover the free status of Trieste, which is not available at any other Mediterranean port, offers a significant competitive advantage to the Ro-Ra customers. In fact free commercial port zone of Trieste is subject to a regime of extraterritoriality, pursuant to which the Italian government cannot limit the flow of international cargo passing through Italy, making it the ideal port for Europe-bound cargo traffic from the Eastern Mediterranean. Given the limited number of annual transit permitted from Italian Government to Turkey, this free status of Trieste is one of the key attractions for Turkish freight operators to use Ro-Ra service.

Ro-Ra operators and terminal specifications

Nowadays three shipping companies operate in Trieste port offering RoRa services from and to Turkish ports: U.N. Ro-Ro, Ulosoy Shipping Group and Ekol Lojistik. The Ro-Ra network connects Turkey with Italy, offering 17 connections per week in total (**Table 7**).

Table 7 - Ro-Ro schedule to/from Trieste, year 2016

Operator	Turkish port	Weekly frequency
U.N. Ro-Ro	Pendik - Mersin	9
Ulusoy	Cesme	3
Ekol	Haydaparsha	5
Total	17	8,213

Source: author's elaborations

U.N. Ro-Ro and Riva Traiana Terminal

This shipping company has been the first to carry out the Ro-Ra service through the port of Trieste. In fact the public association of Turkish truck drivers carried out the first maritime service in 1987 with the Turkish Cargo Line company. Then in 1994, 48 Turkish freight operators formed the private company UND Ro-Ro and in 2004, this company was renamed as U.N.Ro-Ro Isletmeleri Istanbul A.s.

In 2001, U.N. Ro-Ro implemented the complete sea-rail intermodal service, connecting by rail Trieste to Salzburg. In 2013, the shipping company acquired the 60% of terminal operator company "Samer Seaports & terminals Srl", that manages operations in Riva Traiana area, starting a process of vertical integration.

The main innovative characteristic of this service, as explained in the following paragraphs, has been to concentrated on unaccompanied transport by transferring truck drivers by airplane. In this way they obtain ship costs reductions and truck drivers can recover the time of the sea leg (60 hours about).

U.N. Ro-Ro has a fleet of 12 ships (**Table 8**), built between 2001 and 2013, with different characteristics, a growing trailer capacity but the same speed.

Table 8 - The fleet of U.N. Ro-Ro

Vessel Name	Build Year	LOA meter	Lane Meter	Trailer Capacity	Speed (knots)	Flag
UND Ege	2001	193	3214	200	21.05	Turkey
UND Birlik	2001	193	3214	200	21.05	Turkey
UND Atılım	2001	193	3214	200	21.05	Turkey
UN Pendik	2005	193	3735	240	21.05	Turkey
UN Trieste	2005	193	3735	240	21.05	Turkey
Saffet Ulusoy	2005	193	3735	240	21.05	Turkey
UN Marmara	2005	193	3735	240	21.05	Turkey
UN Akdeniz	2008	193	3735	240	21.05	Turkey
UN Karadeniz	2008	193	3735	240	21.05	Turkey
Cüneyt Solakoğlu	2009	193	3735	240	21.05	Turkey
UN İstanbul	2013	208	4094	280	21.05	Turkey
UN İstanbul	2013	208	4094	280	21.05	Turkey

Source: U.N. Ro-Ro data

The U.N. Ro-Ro operates to Riva Traiana Terminal, managed by “Samer Seaports & terminals Srl”, that is based on 100.000 m^2 and has three dedicated ramps for docking. **Table 9** illustrates infrastructural endowments.

Table 9 - Samer Terminal infrastructures and company’s information

Terminal total area (mq)	100.000
Docks (ml)	870
Berths (nr)	3
Rail tracks (nr)	2
Lenght of rail tracks (ml)	400
Tractors unit (nr)	16
Cranes (nr)	4
Shareholding by Ro-Ro shipping companies (%)	60% U.N. Ro-Ro
N. of employees	59

Source: Samer Seaports & terminals Srl data

The U.N. Ro-Ro Mediterranean network connects Turkey with Italy (Trieste and Ancona) and France (Toulon). Concerning Trieste port, U.N. Ro-Ro offers two services with 9 connections per week in total: Trieste/Pendik and Trieste/Mersin (**Table 10**).

Table 10 - U.N. Ro-Ro schedule to/from Trieste, year 2016

Schedule from/to	Weekly frequency
Pendik/Trieste	7
Mersin/Trieste	2

Source: Samer Seaports & terminals Srl data

Ulosoy Shipping Group

This shipping company entered the Ro-Ra market in 1996, connecting Trieste to and from Cesme. Ulosoy has a fleet of 4 ships (**Table 11**), built between 1987 and 2012, with different characteristics. The Ulusoy operates to Trieste Intermodal Maritime Terminal, always managed by Samer and connects Turkey with Italy offering one service with 3 connections per week in total: Trieste/Cesme (**Table 12**).

Table 11 - The fleet of Ulusoy S.G.

Vessel	Build Year	LOA meter	Lane Meter	Trailer Capacity	Speed (knots)	Flag
Saffet Bay	1987	163.80	2760	195	15	Denmark
Ulusoy - 5	1987	163.80	2760	195	15	Denmark
Ulusoy - 14	2012	208.30	4094	283	15	Germany
Ulusoy - 15	2012	208.30	4094	283	15	Germany

Source: Ulusoy S.G. data

Table 12 - Ulusoy schedule to/from Trieste, year 2016

Schedule from/to	Weekly frequency
Cesme/Trieste	3

Source: AP Trieste data

Ekol Lojistik and Europe Multipurpose Terminals

This international freight forwarder is the last to enter the Ro-Ra market in 2013. Before it was a U.N. Ro-Ro customer, then the company decided to start a vertical integration process becoming also ship owners (Alternative Tasimacilik A.s.). Ekol has a fleet of 5 ships (**Table 13**), built between 1999 and 2012.

Ekol operates to Europe Multipurpose Terminals Spa (EMT), established and managed by Francesco Parisi Group, that is based on 70.000 m² total area. EMT Terminal has four dedicated berths, four rail tracks and one 5000 m² warehouse. **Table 14** illustrate infrastructural endowments.

Table 13 - Fleet specifications of Ekol

Vessel	Build Year	LOA meter	Trailer Capacity	Flag
Hatche	2009	193	249	Turkey
Paqize	2010	193	249	Turkey
Qezban	2010	193	249	Turkey
Fadiq	2012	193	249	Malta
Ayshe	1999	199.95	249	Malta

Source: Ekol and Marine Traffic data

Table 14 - EMT Terminal infrastructures and company's information

Terminal total area (mq)	67,635
Docks (ml)	1,038
Berths (nr)	4
Rail tracks (nr)	4
Lenght of rail tracks (ml)	600
Tractors unit (nr)	10
Cranes (nr)	4
N. of employees	48

Source: EMT terminal data

Ekol offers a service with 5 connections per week in total: Trieste/Haydarpasha and Trieste/ Alsancak (**Table 15**). Each trip's duration is 60 hours which is between Haydarpaşa-Trieste ports and also just one trip with 48 hours duration between Alsancak-Trieste ports.

Table 15 - U.N. Ro-Ro schedule to/from Trieste, year 2016

Schedule from/to	Weekly frequency
Haydarpasha/Trieste	4
Alsancak/Trieste	1

Source: Ekol data

The railway leg

After maritime leg, semi-trailers still have to travel more many kilometers to reach final destination, usually over the Alps. Firstly sea-rail transport were performed with RoLa technique, from Farnetti inland terminal to Salzburg. This service is still operational, but later it was introduced rail connection directly from Samer seaport terminal. Existing railway intermodal reports are summarized in the **Table 16**.

Within a few years, Turkish operators developed more unaccompanied services and nowadays there are a several rail traffic connections between seaport terminals and final inland terminals, summarized in **Table 17**.

Table 16 - RoLa connections schedule to/from Trieste, year 2016

Schedule from/to	Weekly frequency
Farnetti terminal/Salzburg	5
Samer terminal/Salzburg	7
Total	12

Source: Terminal Samer data

Table 17 - Rail connections to/from seaport terminal Trieste, year 2016

Seaport Terminal	O/D connections	Weekly frequency
Terminal Samer	Trieste-Duisburg	3
	Trieste-Wells	7
	Trieste-Bettenburg	5
Total		***14***
Terminal EMT	Trieste- Koln	10
	Trieste-Ludwigshafen	7
	Trieste-Frankfurt	2
	Trieste-Muenchen Riem	3
	Trieste-Bettembourg	6
	Trieste-Ostrava	4
Total		***32***

Source: Samer and EMT terminal data

Therefore, number of railway connections in Trieste port are very significant, especially considering that Italian port logistics complains the lack of railways also for container transport, with the only exception of La Spezia.

In order to satisfy this increasing railway transport demand, Trieste Port Authority has expanded piers dimension in order to park a growing number of vehicles and to obtain a more efficient transhipment operations, demonstrating great attention to this type of intermodal transport.

Organization of Ro-Ra system

Concentration of freight flow and vertical integration of shipping management has allowed the implementation of efficient technical solutions in this process of transport activities “industrialisation”. Some of these solutions started at route establishment, others have been taken as the route developed, some others are still in evolution. This logistic pattern could constitute a valuable model for future development of intermodal system sea/rail in other ports and countries.

According to Torbianelli (1999) The most important and interesting technical solutions are described in the following points.

a) Drivers transfer by airplane.

Ro-Ra organization, planning point-to-point all the supply chain, led to charter flights between Turkey and destination country, coordinated with ship-train arrivals and departures. These flights transport truck drivers and avoid drivers inactive aboard the ships or trains. For example, considering a transport on Trieste-Istanbul route, after truck embarkation in the Turkish Port, drivers have two days free for other work, before catching the plane which will take them to Ljubljana. Rented bus take drivers to the Trieste port, where they pick up their truck which has arrived after three days at sea, and head on to their final destination.

b) Trailers without tractors.

The transport of drivers by flight, which was originally the first choice solution, is not the most efficient because transporting tractor cabin involve locking-up cost and takes up space. Therefore, many Turkish road transport companies decided to open branch offices in European destination countries or to join in cooperation with other firms to share. The scope is to manage road transport until final destination without loading tractors on the sea-rail leg. This way offers a flexible way to manage tractors fleet and to reach more efficiency in firm organization. At present accompanied solution covers approximately 40% of traffic, the remaining 60% is unaccompanied.

c) Use of railways.

Considering that Turkish traffic concerns mainly Northern range (Austria, Germany, Netherlands, Great Britain), rail is a good solution for land transport. This mode preference depends also on road limits imposed by Austria, that reimburse rail transport cost to companies. The train is assembled in Trieste port, that is also connected to inland rail terminal Fernetti.

This Ro-Ro service through Trieste, excluding some solvable problems relating to gabarit dimension and relationship with railway companies, is an efficient alternative logistic solution. Moreover, RoLa for accompanied land haulage is an outdated method. Instead, as a feeder of maritime transport, RoLa could encourage road transport companies to organize unaccompanied rail transport to inland terminals in the heart of Europe.

Advantages of Ro-Ra system

The Adriatic Ro-Ra service seems to have a greater potential for development compared to the more traditional system of container transport for following reasons:

- Ro-Ro is time efficient: at present Turkey-Europe requires six days, whilst a container takes about twenty days. This is particularly relevant in a market "just-in-time" (JIT) oriented. The time saving is due to three main reasons: (1) Ro-Ro maritime routes are shuttles and without complex overlapping of flows which is the case with containers, that better exploit handling economies of scale, but involve transhipment and frequent waiting time. (2) Ro-Ro vessels can keep high speeds without prohibitive costs of containers longer routes. (3) the ship-train transshipment takes place directly on the dock, avoiding loading breakages of Lo-Lo ships.
- Ro-Ra allows the Turkish road transport companies to maintain the control of the whole distribution chain, because the need for outsourcing inland road transport to and from Trieste port is eliminated.

Concluding Remarks

The Ro-Ra solution is an alternative to all-road transport, but this kind of service is operational in Europe only in a limited number of ports. This paper has studied competitiveness in sea-rail market of European ports, collecting infrastructural data by interviewing terminal operators and port authorities.
The analysis process has involved a sample of 19 ports and has estimated a performance index for measuring port competitiveness by applying the PCA technique. This indicator allowed us to draw up a European port classification on the basis of infrastructural elements, represented by eight variables.
Even if results related on database are fragmentary, due to several missing values, with consequences of representativeness, it is possible to draw some preliminary considerations. In order to validate results, it will be necessary to complete database with missing infrastructural information and with rail traffic statistics.

First of all the analysis confirm that rail connections quality and handling equipments are key variables for port competitiveness. Also operators confirm this result. In fact, above variables allow a high loading/unloading rate and inland forwarding. In confirmation of this and in line with other studies results, frequency and time seem to be key attributes in the mode choice process.
According to this estimation, which should be considered with appropriate skepticism, ports of special interest are Zeebruge, Rotterdam and Le Havre. This result confirm the infrastructural efficiency of Northern range ports, which are included in European TEN-T core network. Also port of Koper registers a reasonable value for PPI indicator despite has entered this market only in 2015. Therefore it has great potential to increase sea-rail traffic. On the other hand, ports of London and Valencia, included in the core network, register a below-average indicator value.
Moreover this study highlights that, even when there is considerable Ro-Ro throughput, several European and especially Italian ports do not have adequate infrastructure or equipment for this traffic. In many cases there is no terminal rail connections. While in Northern Europe there are large Ro-Ra terminal with specific equipment, in Italy these terminals are still not considered strategic for port and economy development, with the only exception of Trieste. This paper dedicated to this case of success a focus to understand in details its peculiarities.
The presence of important shipping lines in this market may positively contribute to sea-rail sector development, in order to innovate logistics and supply chains among European countries. In Italy, indeed, considerable confusion appears to persist in considering sea-rail intermodal services, which finds its origin in planning and public financing of unsuccessful inland distripark. Ro-Ro-Rail represents a segment of intermodal market which is scarcely developed in Italy.
In conclusion, taking into account these preliminary estimations outcome, it appears that in order to improve port efficiency and competitiveness, it is important focus on actions which increase rapidity and frequency of sea-rail transport service. This analysis focused on a topic on which there is a scarcity of scientific literature. However, it is necessary more research work in order to consider also traffic volumes and to estimate efficiency also for individual terminal operators. In fact, lack of specific official data and terminal operators companies reluctance to participate in the survey, do not permit the segmentation of Port Performance Index. Moreover the focus on a European area has limited the population of terminal operators and port authorities, who could be interviewed.
Author feel that more work is necessary to better estimate sea-rail terminal and port efficiency. In particular, it is desirable in future research to overcome reluctance barrier, perhaps with a more direct contact, in order to interview in a sufficiently large number Ro-Ro-Rail terminal operators companies.

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