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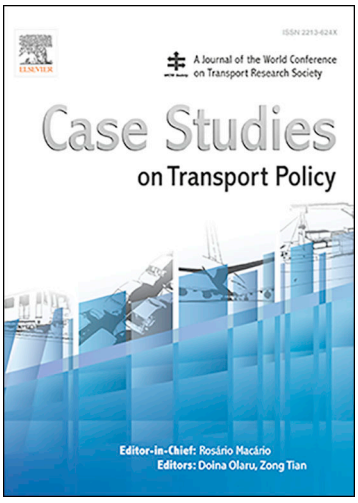

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PII: S2213-624X(23)00014-7
DOI: https://doi.org/10.1016/j.cstp.2023.100960
Reference: CSTP 100960

To appear in: *Case Studies on Transport Policy*

Received Date: 28 May 2021
Revised Date: 9 January 2022
Accepted Date: 20 January 2023

Please cite this article as: F. Russo, G. Musolino, V. Assumma, Ro-ro and lo-lo alternatives between Mediterranean countries: factors affecting the service choice, *Case Studies on Transport Policy* (2023), doi: https://doi.org/10.1016/j.cstp.2023.100960

Ro-ro and lo-lo alternatives between Mediterranean countries: factors affecting the service choice

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Abstract
A relevant portion of the scientific literature on Short Sea Shipping (SSS) focuses on the competition of SSS against land transport. In the field of competition, great importance assumes the presence of international programmes that define land and maritime corridors as the TEN-T.
The SSS market is defined by two main services: roll on–roll off (ro–ro) and lift on–lift off (lo–lo) services, differing in the typology of loading/unloading of units of load to/from the ships. The paper analyses the competition inside the maritime SSS market, comparing ro-ro vs lo-lo.
A discrete choice model, simulating the split between ro–ro and lo–lo services of freight flow exchanged by sea between some Mediterranean countries has been developed, updating old values, previously calibrated, by means of a new dataset. New data, regarding freight flows exchanged by sea between Italy and some MENA countries, transported by lo–lo and ro–ro services, were obtained from EUROSTAT (year 2019).
The paper presents the advancement of a research line whose general objective is the evaluation of geographic factors affecting the maritime services in (closed) sea basins.
The proposed analysis could support the decisions of maritime transport operators (e.g. shipping lines, carriers, …), who operate with unitised cargos. It could be also suitable to support the analysis of market penetration of the analysed maritime services in other sea basins, such as the Baltic or the Northern ones in Europe. At the end, it could contribute to provide quantitative support to transport planning activities in progress at Euro-Mediterranean level.

Keywords: *Short Sea Shipping, lo-lo and ro-ro services, discrete choice model, Mediterranean Sea.*

1. Introduction

The global maritime trade maintained over the years the structure that was largely rooted in the 1980s (Figure 1). Main solid bulks, including iron ore, grain and coal, increased with a relative constant grow rate. Containerized cargo expanded at the fastest rate, with volumes rising at an annual average rate of about 5%.
The transport of containers on an intercontinental scale takes place by means of large specially built ships that do not have cranes on board for loading and unloading the containers. These ships have to dock in specialized ports that have adequate harbour cranes and large shipyards. For short-medium distance movements, nationally or internationally, ships used are often equipped with on-board cranes. On short-medium distances, container transport is also carried out by articulated lorries, or in any case on wheeled trailers, via specially equipped ferries. In the first type, loading

and unloading takes place with vertical lift movements, specified as lift-on and lift-off, from which they take the name of lo-lo. In the second type, loading and unloading take place through horizontal roll-on and roll-off movements, from which they take the name of ro-ro.
Short Sea Shipping, abbreviated in SSS, is the shipping of goods over relatively short distances, in contrast to intercontinental shipping across the oceans, called Deep Sea Shipping (CE, 1999).

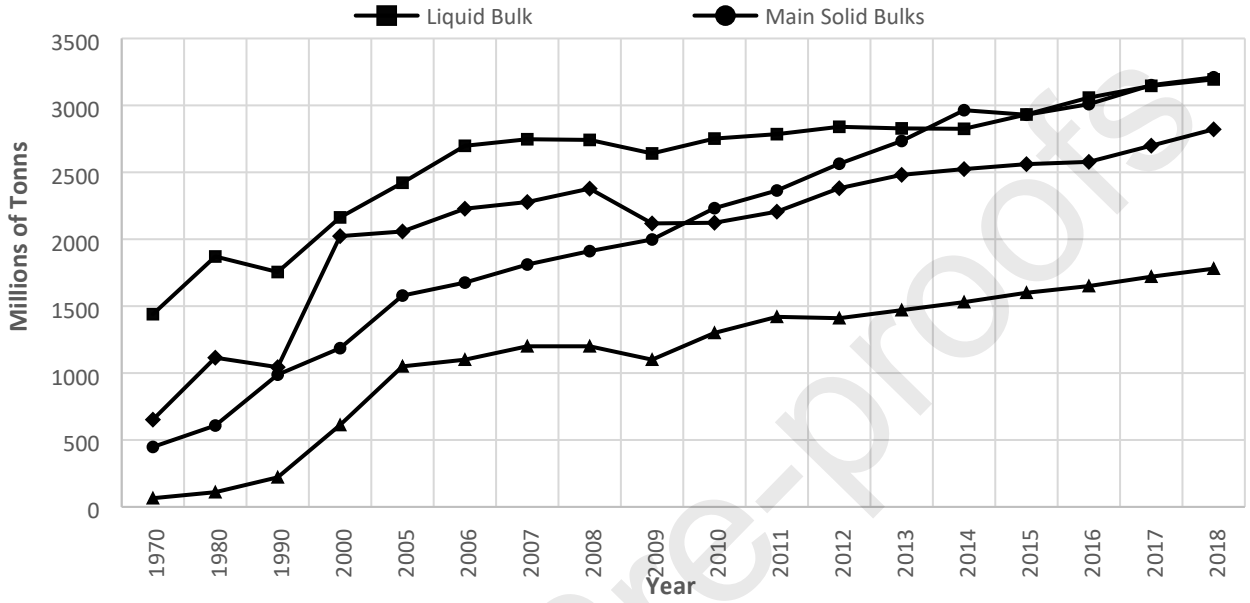


Figure 1. Historical trend of global trade market for the main cargo types (Millions of Tonns). Main solid bulks: Iron ore, coal, grain, bauxite and alumina, and phosphate rock; Liquid bulk: Crude oil, refined petroleum products, gas and chemicals; Other dry cargo: Minor solid bulks and residual general cargo (Source: UNCTAD, 2019).

The SSS market in the Mediterranean is particularly rich and still tends to grow. The two basic components are represented by the ro-ro and lo-lo services. It is worth noting that, while there are often financial supports provided by EU for the services that connect two European countries, no financial incentives are available for connections with other Mediterranean countries.
Many studies have been developed for short sea shipping, the two main themes developed concern:

- the competitiveness of the SSS within the EU, due to European funding programs;
- the structural factors affecting the competitiveness of the SSS.

Regarding the competitiveness of the SSS at EU level, it is necessary to consider that the SSS always presents itself as an alternative to land transport. To build homogeneous corridors and promote adequate services, the EU has launched specific financial support programs. The corridors, on which the financially supported SSS services are carried out, are defined as Motorways of the Sea (MoS). It is worth noting that the definition of SSS in the EU includes also services to countries across the Mediterranean Sea; but only if the conneceted countries belong both to EU, the services can be financially supported.
The analysis of Motorways of the Sea has been developed in the literature following both a more qualitative approach and a quantitative analysis.
Among the qualitative set, the work of Casaca and Marlow (2007) evaluates the impact of the TEN-T networks on SSS. To achieve this, the paper describes the SSS market segment. It puts into a historical perspective the TEN-T policy, and it carries out an assessment of the impact of the TEN-T on SSS. In the same way Baird (2007) evidenced that substantial public sector investment in roadway

and railway infrastructures throughout the EU have been made, and that the seaway has tended not to be supported with the same intensity, due to the wrong assumption by policymakers that the seaway represents a kind of free highway, and therefore it should not be object of public subsidies as roadways and railways are. According to this distortion, Baird noted that EU changed approach and considered that SSS offers the potential to hold back the dramatic growth in road freight transport, as EU began to be more positively in favor of maritime intermodal transport solutions. After some years, Douet and Capuccilli (2011) explained how the lack of a final definition has led to inadequate public policies favoring modal transfer in the EU and how the lack of knowledge of SSS markets has led to an overestimation of the modal shift potential.

After the literature developed in the first years of MoS that introduced the problem, some papers have been published that analyzed the quantitative aspects.

Lopez Navarro et al. (2011) on the basis of a sample of international road transport firms that use SSS between Spain and Italy, analyze the profile of these firms and the main attributes according to the two ways of organizing their SSS, of ro-ro type, transport operations: accompanied versus unaccompanied. Suárez-Alemán et al. (2015) establish that EU funding programs have not properly offered the right incentives to promote SSS, because the key role of ports and their characteristics, have not been taken into consideration. They use a theoretical intermodal competition model to compare alternative modes—road transport vs. SSS, concluding that the EU needs to focus on ports and transport system efficiency as a whole in order to compete effectively in the freight transport market. Marzano et al. (2020) propose an in-depth analysis of ro-ro/ro-pax services in the Western Mediterranean, with a focus on Italy, and estimate freight flows between ports of the examined countries. Serra and Fancello (2020) compared a hypothetical Mediterranean ro-ro SSS network developed in the framework of a past Euro-Mediterranean cooperation project with the network of existing ro-ro liner services operating in the area. The comparison of the two networks is performed using a set of quantitative key performance indicators and applying a factor-cluster analysis.

The problem of the MoS, defined as European maritime corridors of the SSS, has been developed in the literature, but various aspects have not been investigated due to the presence of public contributions in the MoS. it is interesting to recall some works that consider the structural factors that influence the SSS in an open market: first, some recalled works present a qualitative approach; and, secondly, other works analyze the quantitative aspects.

The work of Paixao and Marlow (2005) focus their research on how to increase the competitiveness of SSS within European multimodal logistics supply chains, after observing that a low shift from road to sea has been obtained. They identify and analyze the main service attributes of SSS operations by means of an empirical research, involving logistics operators, shippers' associations and intermodal rail operators. A literature review showing how SSS can alleviate traffic congestion and enhance economic development by maintaining freight flow efficiency is presented by Medda and Trujillo (2010), evidencing that SSS is considered to be one of the most sustainable and economically competitive modes of transport.

The first systematic review of the quantitative evaluation of freight transport attributes associated to different modes and services is proposed in Russo (2005). A specification of the attributes for sea freight transport on a Mediterranean scale with the calibration of a demand model are reported in Russo and Assumma (2005). The work of García-Menéndez and Feo-Valero (2009) aims to find the determinants of mode choice decisions for shipments between Spain and the rest of Europe using a modal choice model, where the two modes considered are road transport and short sea shipping. The paper of Morales-Fusco et al. (2012) analyzes how the strategy, taken by the cargo carrier when using Motorways of the Sea (defined as regular roll on/roll off short sea shipping lines), affects the competitiveness of the shipping lines. Three main types of strategies are considered: road door-to-door transportation, combined road-sea transportation with a driver always accompanying the

cargo, and combined road-sea transportation where the cargo travels unaccompanied. An aggregate discrete choice model, has been specified and calibrated by Russo et al. (2016) simulating the split between ro–ro and lo–lo services of freight flow exchanged by sea between countries facing the Mediterranean basin. The important element that emerges is the segmentation of the market in relation to the distances existing between each couple of countries. Konstantinus and Zuidgeest (2019) consider the freight modal choice in the Southern Africa. The results of a logit model revealed that the main attributes in terms of importance are reliability with reference to arriving on time, transport cost, risk of damage, frequency of service and transit time. Based on statistical and regression analyses, Tao and Zhu (2020) explore the factors that affect VOTs at the macro/micro level, considering ro-ro and lo-lo services. An assessment methodology is proposed in Comi and Polimeni (2020), which develop an aggregate discrete choice model simulating the split between the competitive transport alternatives inside the Mediterranean basin. Two future scenarios are considered: introduction of new SSS services as envisaged by current EU projects and plans, and the introduction of new SSS routes and an increase in frequencies of existing services. Lupi et al. (2020) discuss the main characteristics of MoS in Italy, by analyzing and comparing existing ro-ro and ro-pax routes calling at Italian ports. Moreover, the competitiveness of intermodal transport, with embedded MoS, against all-road transport, is quantitative analyzed for the case of the Ligurian region (Italy). The results show that the current intermodal alternative is not competitive, although some scenarios that include fare integration, route integration and new MoS routes, seem to make the alternative more competitive. Santos et al. (2021) present a methodology to support the design of SSS services, which are part of intermodal door-to-door transport chains. The methodology is composed of the following steps: estimation of freight transport demand between O–D pairs; allocation of estimated demand to transport chains according to a logistic model that considers transport costs and times; quantification of the right ship size. An application is carried out for the case of a ro–pax service between Portugal and Morocco. Giuffrida et al. (2021) assess the environmental impact of container port terminal, starting from the types of container services.

On the basis of the literature, it emerges that the existing studies concern, in summary, SSS services between EU ports, MoS funding, and competition with land transport. On the other hand, the problems concerning the choices in the context of the SSS when there are no public financial supports are still open. It is particularly important to have updated information about the structural factors of the two main service alternatives in the context of the SSS: namely ro-ro and lo-lo. The updating must be developed on the basis of the choices made by the shippers. The value of the main parameters relating to the services attributes, therefore, should be updated.

The remaining part of the paper is articulated as follows. Section 2 is dedicated to the analysis of historical trends of freight transported inside the Mediterranean Sea in the last twenty years. The focus is on import and export trade from Italy to some countries of the Southern and Eastern Mediterranean Sea (MENA countries). Section 3 addresses the main research question posed in the paper: which are the structural factors that affect the choice between ro-ro and lo-lo alternative services? The alternatives are firstly defined by presenting their characteristic attributes; then the formulations used for the calculation of the attributes are presented. The choice model among the available alternatives is, then, specified. The model was previously built with observed traffic data of year 2010 (see Russo et al., 2016). A GLS estimator (Cascetta and Russo, 1997; Cascetta, 2009; Russo and Vitetta, 2011) allowed to update the model parameters against observed traffic data of year 2019. Finally, section 4 reports the conclusions and the research perspectives.

The results obtained in this research, on the one hand, make it possible to draw some insights about the characteristics of the two services; on the other hand, they may be transferred to analyze other geographical areas (e.g. the Baltic and the Northern Seas in Europe), where SSS services operate in

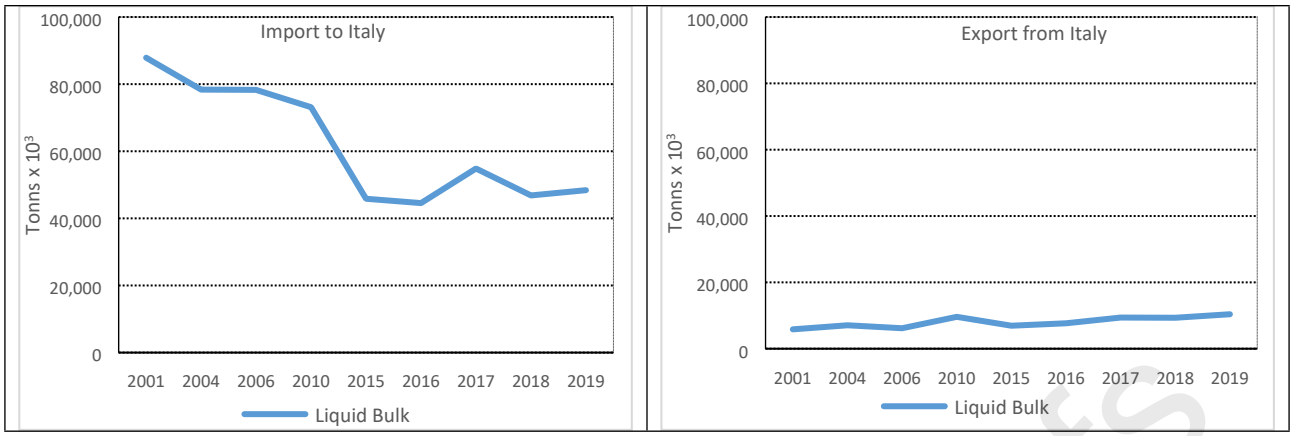
the absence of public funding. The work is therefore particularly useful for both researchers and planning technicians.

2. SSS freight traffic in the Mediterranean area: the case of Italy

The analysis presented in this section concerns historical trends (years 2001-2019) of freight traffic exchanged between Italy and some Southern and Western Mediterranean countries (see Figure 2): Malta, Tunisia, Algeria, Libya, Egypt, Israel, Cyprus, Morocco, Lebanon, Jordan, Turkey and Syria.

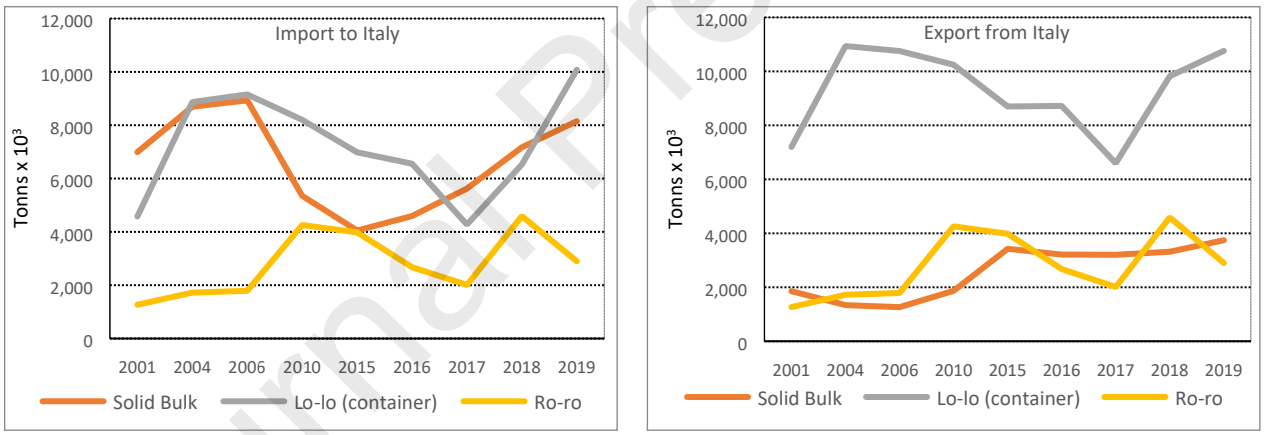
Figure 2. Map of Mediterranean Sea and MENA countries (source: https://www.alamy.it, access: 13th April 2021).

The freight flows (Tonsx10^3) exchanged by sea are subdivided by type: liquid bulk, dry bulk, lift on-lift off (container), roll on-roll off. The source of data is Eurostat (www.epp.eurostat.ec.europa.eu). The historical trend of liquid bulk in import to Italy and in export from Italy is depicted, respectively, in Figures 3.a and 3.b. The amount of liquid bulk traffic in import to Italy is predominant respect to the export, and to the other cargo segments. The decline in import in the last years was due to political instabilities of some countries, like Libya and Algeria, known as “Arab Spring”, that are traditional suppliers of Italy.



Figures 3.a-b. Freight traffic in import to Italy (a) and in export from Italy (b) of liquid bulk. Years 2001-2019.

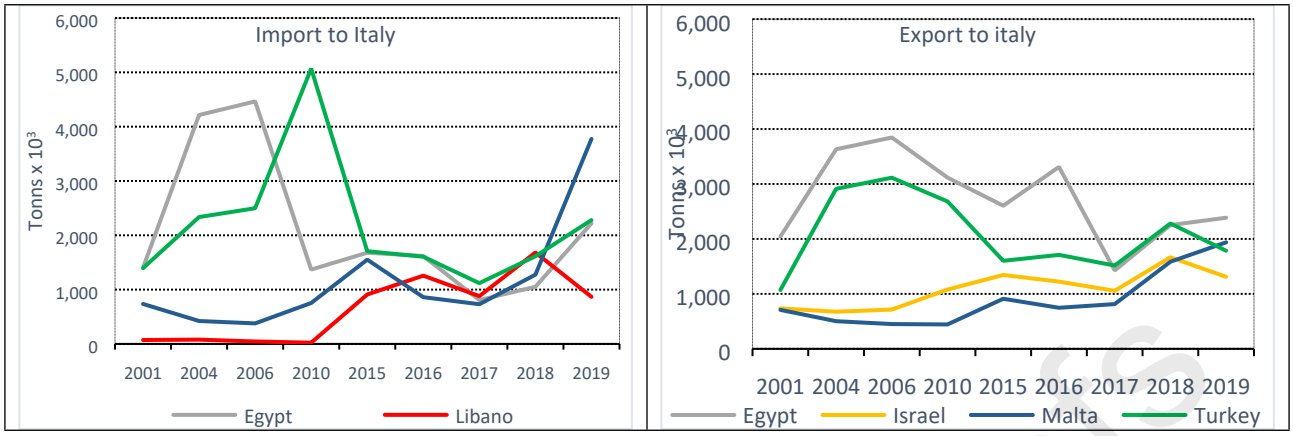
The historical trend of freight traffic of solid bulk, containerized freight (lo-lo), and freight transported via ro-ro services in import and in export to/from Italy is depicted, respectively, in Figures 4.a and 4.b. The amount of freight for the solid bulk and containerized categories imported in Italy declined between years 2010 and 2015 and increased again after 2015; while the level of export from Italy was more stable during the whole period. In general, the oscillations were generated by the above introduced "Arabian Spring", that involved some African countries like Egypt, Libya, Tunisia and Algeria and by the last effect of 2007-2008 crisis.



Figures 4.a-4.b. Freight traffic in import to Italy (a) and in export from Italy (b) of solid bulk, containerized freight (lo-lo), and freight transported via ro-ro services (ro-ro)*. Years 2001-2019.*

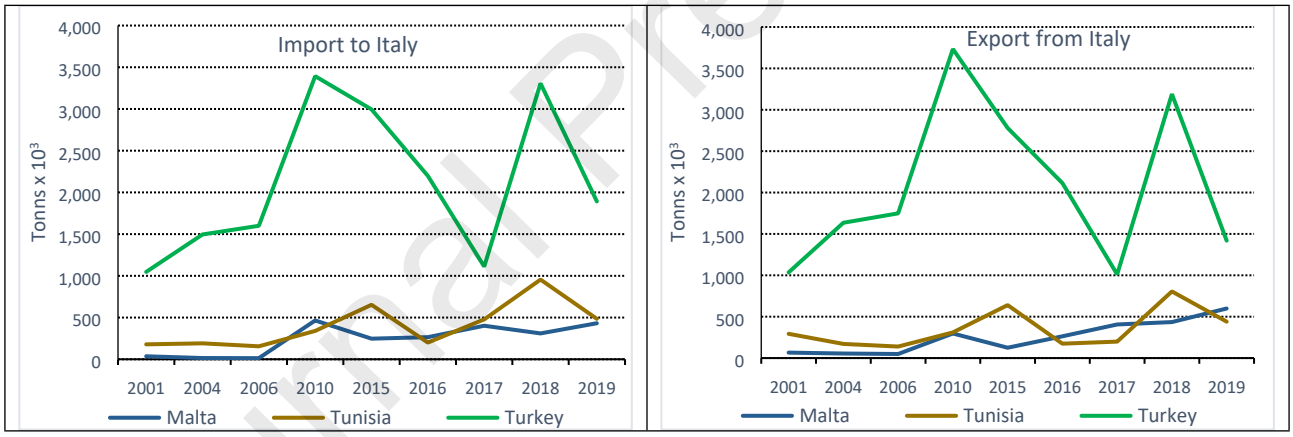
As far as concerns container (lo-lo) traffic, the historical trend of the main containerized freight flows exchanged with Italy is depicted in Figures 5.a, for the import from Italy, and 5.b, for the export from Italy. The main countries from which Italy imports containerized freight are: Egypt, Lebanon, Malta, Turkey; while the main countries where Italy exports containerized freight are: Egypt, Israel, Malta, Turkey.

As reported above for the general trend, the amount of containerized freight imported in Italy from Egypt and Turkey declined between years 2010 and 2015 from a peaks ranging from 4.000 and 5.000 [Tonnsx10^3] to 1.000 [Tonnsx10^3]. While for Egypt the oscillations could be more directly generated by the political instability, the case of Turkey is more specifically connected with geo-political and commercial relationships between Turkey and the EU. It is worth noting that the level of import from Malta increased, passing from 1.000 and almost 4.000 [Tonnsx10^3] in 2019. The level of export from Italy was more stable during the whole period.



Figures 5.a-5.b. Freight traffic in import to Italy (a) and in export from Italy (b) of container freight (lo-lo). Main countries in import: Egypt, Lebanon, Malta, Turkey. Main countries in export: Egypt, Israel, Malta, Turkey. Years 2001-2019.

The historical trend of freight traffic of freight transported in import to Italy and in export from Italy via ro-ro services is depicted, respectively, in Figures 6.a and 6.b. The main countries are: Malta, Tunisia, Turkey. The trend of freight traffic with Malta and Tunisia both in import and in export is stable and balanced around levels of 500 [Tonnsx10^3]; while the level of traffic with Turkey was variable, as stated above.



Figures 6.a-6.b. Freight traffic in import to Italy (a) and in export from Italy (b) of freight exchanged via ro-ro services. Main countries: Malta, Tunisia, Turkey. Years 2001-2019.

3. Model

The decisive role of the SSS within the Mediterranean basin emerges from the data presented in the previous sections. As seen, the two main services that make up the SSS are the ro-ro and the lo-lo. It is therefore necessary to identify what are the structural factors that influence the choice between ro-ro and lo-lo services. In order to bring out these factors clearly and to verify their impact, it is necessary to define the alternatives by specifying their characteristic attributes, and by presenting the calculation method of the attributes. After having calculated the attributes, it is possible to specify the choice model between the two alternatives.

The mode-service choice model simulates how OD flows spilt among the different available maritime transport mode-services. The proposed model is a multinomial logit where the expected value of perceived utility associated to the alternatives, is a linear combination of parameters and of attributes.

The choice set is composed by two available maritime mode-services: container or lift on-lift off (LOLO), roll on-roll off (RORO). The model estimates the probability of using a mode-service m, without considering the choice of a specific services (in this last case it should be necessary a schedule-based approach in order to model the supply of services, as in Cascetta et al. 1995).
In this work the term mode-service is used to indicate the single alternative. This allows to indicate the alternative (ro-ro or lo-lo), without indicating the single service, which usually identifies a specific navigation line between the ports. The use of mode-service allows not to mislead. The study of the choice between services requires a frequency-based schematization of the supply system (Cascetta et al., 1996), or a deeper scheduled-based approach.
The role of competition between shipping companies along the different routes, and therefore of the number of operators both in the lo-lo and in the ro-ro market, is particularly important and can be studied in the context of service choice models, assuming the mode-service to be fixed, with the above recalled frequency or scheduled-based approaches (Cascetta et al. 1995, 1996).

3.1. Specification and attributes estimation

The service model is specified using a logit formulation; it provides the probability, p_m, that freight travels with service m:

$$p_m(\beta) = \exp(E[U_m(\beta)]) / (\Sigma_{m \in M} \exp(E[U_m(\beta)])) \quad (1)$$

where $U_m(\beta)$ is the perceived utility associated to the choice of service m, dependent on vector β;

with
$E[U_m]$, expected value of perceived utility U_m;
M, choice set of alternatives (e.g. M= {lo-lo, ro-ro});
β, vector of model parameters.

The expected value of perceived utility U_m is expressed as:

$$E[U_m] = \Sigma_i \beta_i x_{m,i} \quad (2)$$

where:
$x_{m,i}$, measurable attribute i of maritime service m;
β_i, parameter associated to attribute i, defined as component of vector β.

The following specification has been considered:

$$E[U_{lo\text{-}lo}] = \beta_c c_{lo\text{-}lo} + \beta_t t_{lo\text{-}lo} + \beta_{HUB} HUB \quad (3.a)$$

$$E[U_{ro\text{-}ro}] = \beta_c c_{ro\text{-}ro} + \beta_t t_{ro\text{-}ro} + \beta_{SERV} SERV \quad (3.b)$$

where:
$c_{lo\text{-}lo(ro\text{-}ro)}$, monetary cost of transporting freight from a country of origin to a country of destination by means of lo-lo (ro-ro) service;
$t_{lo\text{-}lo(ro\text{-}ro)}$, travel time of transporting freight from a country of origin to a country of destination by means of the lo-lo (ro-ro) service;

HUB, specific attribute of lo-lo service which is equal to 1 if one country has a container transhipment port that offers direct services towards East Coast of USA and Far East with at least one million of TEUs handled per year, 0 otherwise;

SERV, specific attribute of the ro-ro service which is equal to 1 if there is a high-frequency service (at least twenty-five connections per week) between the pair of countries, 0 otherwise; the overall number of ro-ro services between the different pairs of countries is calculated with reference to both ro-ro and ro-pax services; given that the loading of heavy vehicles is expressly allowed in ro-pax services.

The travel times and the monetary costs are estimated by means of cost models present in literature (Russo, 2005) and updated in the context of this work, as reported below.
The average travel time for a ship (lo-lo/ro-ro), t_{rs}, is estimated as:

$$t_{rs} = \alpha_1 \cdot d_{rs} \text{ (days)} \quad (4)$$

with
r, country of origin
s, country of destination;
d_{rs}, average distance between the origin-destination countries r and s (in nautical miles),
α_1 average speed of ships (to be calibrated).
The average monetary cost for a carrier to transport one container (TEU) with a container ship, $c_{rs,lo\text{-}lo}$, is estimated as:

$$c_{rs,lo\text{-}lo} = \alpha_2 \cdot d_{rs} + \alpha_3 \text{ (Euro)} \quad (5)$$

with
α_2, monetary (variable) cost for one TEU per unit of distances (to be calibrated);
α_3, monetary (fixed) cost for one TEU (to be calibrated).
The average monetary cost for a carrier to transport one trailer (of length of 18.35 m) with a ro-ro ship, $c_{rs,ro\text{-}ro}$, is estimated as

$$c_{rs,ro\text{-}ro} = \alpha_4 \cdot d_{rs} + \alpha_5 \text{ (Euro)} \quad (6)$$

with
α_4, monetary (variable) cost for one trailer per unit of distances (to be calibrated);
α_5, monetary (fixed) cost for one trailer (to be calibrated).
The distances, d_{rs}, are calculated between the largest centres of production or consumption of each country, through existing shipping routes (see Tab. 1). An average value between the centres is calculated for countries having two or more centres of production-consumption (Microsoft Encarta Interactive World Atlas 2000).

Tab. 1. Values of average distances (d_{rs}) and of dummy attributes (eqs. 3).

	Distance (d_{rs}) [mph]	HUB [0/1]	SERV [0/1]
Malta	644	1	1
Tunisia	882	0	0
Algeria	1102	0	0

Libya	1347	0	0
Egypt	1555	1	0
Israel	1631	0	0
Cyprus	1652	0	0
Morocco	1656	0	0
Lebanon	1688	0	0
Turkey	1798	0	1
Syria	1968	0	0

The presence of a container hub transhipment port (attribute HUB in Eq. (3a)) and the high-frequency of ro–ro services (attribute SERV in eq. (3b)) are estimated at country level.
The countries having ports with direct lo-lo deep-sea services towards East Coast of USA and the Far East were Malta and Egypt. The attribute HUB is set to 1 for these two countries. The presence of a hub transhipment port generates a number of feeder lines that could deliver containers towards regional destinations located inside the Mediterranean Sea.
The attribute SERV is calculated by considering the ro–ro services connecting the Italian ports and the following ports: Cesme, Hydarpasa, Mersin, Pendik and Tekirdag (Turkey); Tartous (Syria); Alessandria (Egypt); Tripoli (Libya); Tunis (Tunisia); La Valletta (Malta); Tangier (Morocco). The countries connected with high-frequency ro–ro services are Malta and Turkey, therefore the attribute SERV is set to 1 for these countries.

3.2. Parameters' calibration

The vector of parameters $\boldsymbol{\beta}$ (in eq.1) was calibrated by means of observed data of year 2010 in a previous work (Russo et al., 2016). The vector $\boldsymbol{\beta}$ is now updated with observed data of year 2019 by means of a nonlinear Generalized Least Square (GLS) estimator (see Cascetta and Russo, 1997; Cascetta, 2009; Russo and Vitetta, 2011, for the theoretical background):

$$\boldsymbol{\beta}^* = \arg\min_{\beta \in S_\beta} \left[w_\beta \Sigma_i (\beta_{0,i} - \beta_i)^2 + w_d \Sigma_{rs} \left(\frac{d_{rs,m}}{d_{rs}} - p_m(\boldsymbol{\beta}) \right)^2 \right] \quad (7)$$

where
$\boldsymbol{\beta}^*$ is the optimal vector of parameters;
β_i is the current parameter i (of vector $\boldsymbol{\beta}$) to be calibrated;
S_β its feasibility set of the parameters;
$\beta_{0,i}$ is the value of the parameter i previously calibrated (see Table 2 below);
$d_{rs,m}$ is the observed freight flow between the couple of countries rs, having Italy as origin or as destination, with maritime service $m \in M$ (e.g. M= {lo-lo, ro-ro});
d_{rs} is the observed freight flow between the couple of countries rs, having Italy as origin or as destination;
$p_m(\boldsymbol{\beta})$ is the percentage/probability associated to use of service m (model of eq.1), which is function of vector of parameters $\boldsymbol{\beta}$;
$w_\beta$is the weight associated to the first component of the sum inside the square brackets;
$w_d$is the weight associated to the second component of the sum inside the square brackets.

3.3. Results and discussion

The model (eq.1) was updated with the GLS method (eq. 7), obtaining the aggregate shares of lo-lo and ro-ro services between Italy and the set of examined countries.

Firstly, the aggregate (average) observed shares, $d_{l,m}$/ d_l, were obtained from available observed traffic data of year 2019 (www.epp.eurostat.ec.europa.eu); then, the vector of parameters, **β**, was estimated by solving the eq. 7.

The results of vector **β** updating by means of observed data of year 2019 are presented in table 2, together with the first calibration obtained by means of observed data of 2010.

The elements that emerge for the updated parameters are the following. In general, the numerical results suggest that, under a wide range of hypotheses on the information contained in eq. 1, the GLS estimator provide acceptable results (Cascetta, 2009). The sign of the generic attributes, travel times and monetary costs, is still negative in case of both import and export directions, reducing the estimated utility of the model (eq.1) as a result of increasing value of costs. The specific variables, HUB and SERV, maintain their positive signs for both directions, increasing the estimated utility of the model (eq.1) associated to the alternative having the attribute equal to one.

The Value of Time (V.o.T), defined as the ratio β_t/β_c, changes from year 2010 to 2019 as follows. The V.o.T. increases in the import direction, with an increment of 52,5%, while it increases in the export direction, with an increment of 84,3%. The values of V.o.T. obtained are in line with those presented on an international scale (see Tao and Zhu, 2020; Santos et al., 2022), considering that the value reported in tab. 2, in line with eqs. (4), (5) and (6), refer to one day and to one TEU (or trailer). As recommended by the literature, they must be carefully used in the application as they are obtained as average values among those specific of the single alternative.

The reason could be connected to the increasing value of transported freight, during the 2010-2019 decade and with the increasing risk cost for political instability.

The ability to reproduce the observed data for year 2019 was measured by the coefficient of determination: $R^2 = 1 – RSS/TSS$, where RSS, is the residual sum of squares between observed and estimated data; TSS, is the total sum of squares between observed data and their average value.

The values of R^2 are respectively 0,80 and 0,97 for import direction and export directions. They cannot be compared with the R^2 of year 2010, as the previous calibration was obtained with a log-likelihood approach (see Russo et al., 2016). In both cases, the high quality of the model, and therefore of the updated parameters, is connected with the traffic volumes which are significant on the different r / s relationships and which are well estimated ex-post with the calibrated model.

Table 2. Calibrated parameters of eq. (1) with observed data of years 2010 and 2019.

		2010(*)		2019	
	Unit	Import to Italy	Export from Italy	Import to Italy	Export from Italy
β_t	1/day	-0,8911	-0,5466	-2,051	-1,603
t-stud		-4,6	-4,3	--	--
β_c	1/€	-0,0045	-0,0051	-0,007	-0,008
t-st		-8,7	-14,0	--	--
β_{HUB}	util	1,322	1,864	3,964	3,314
t-st		5,0	8,0	--	--
β_{SERV}	util	2,255	3,332	3,827	4,556
t-st		6,7	14,8	--	--
V.o.T (β_t/β_c)	€/day	198,1	107,2	302,1	197,6
In.LL$^{(\#)}$ (RSS)		-862,28	-1028,63	(0,495)	(0,328)

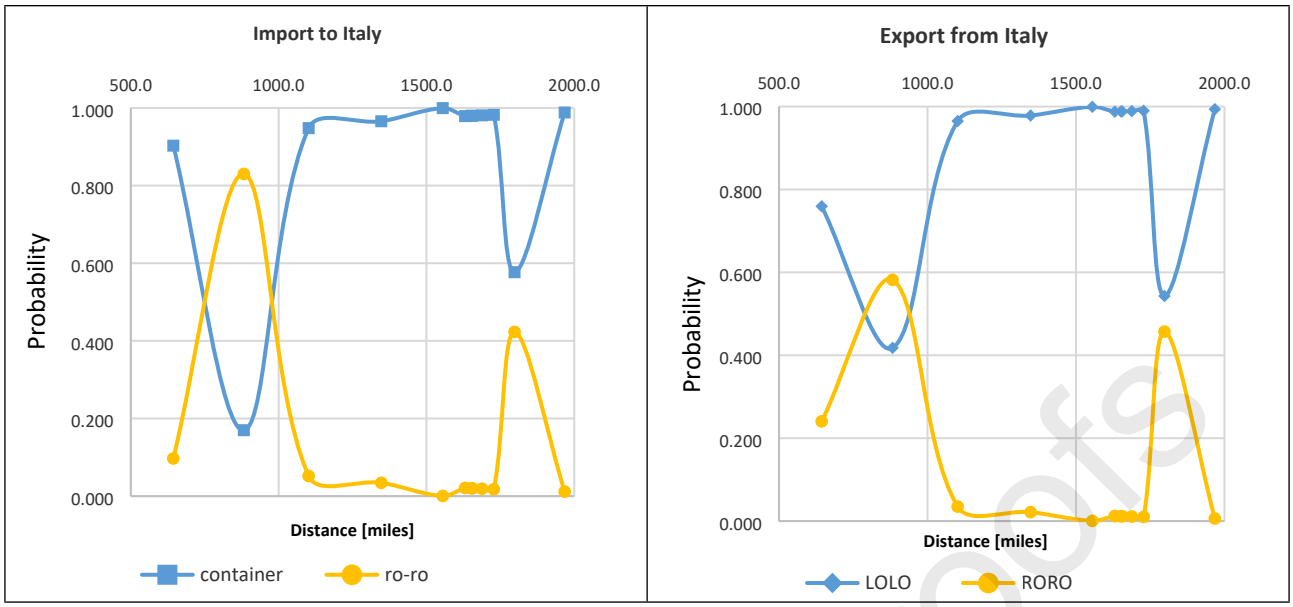
Fin.LL(#) (TSS)	-723,29	-654,27	(0,098)	(0,011)
R^2	0,16	0,36	0,80(**)	0,97(**)

(*) see Russo et al. (2016) for comments about model and parameters calibrated with observed data of year 2010.
(#) log-likelihood, (**) coefficient of determination.

The figures 7.a-7.b show the values of estimated shares between the two services estimated by eq. (1) with calibrated parameters by means of observed data of year 2019. The shares are plotted against average distances between Italy and each country. In broad terms, two areas of the diagram can be identified:

- for distances lower to 1000 miles, that include Malta and Tunisia, the estimated share of ro-ro services is relevant and it is more accentuated with Tunisia, where it reaches values of 82% in import and 58% in export (the shares of ro-ro services for Tunisia were 54% in import and 33% in export for year 2010, as reported in in Russo et al., 2016);
- for distances greater than 1000 miles, that include all the other countries, the share of lo–lo service is very close to the value of 1.0, except to Turkey where the share of ro-ro services is 42% in import and 46% in export (similar shares were estimated for year 2010: in particular, the share of ro-ro services was 39% in import and 58% in export for Turkey, as reported in Russo et al., 2016).

This pattern, at aggregate level, seems to be in line with the characteristics of the two services: the container service tends to be more convenient than the ro–ro one for greater distances. As matter of fact, the transport of tare associated to ro–ro implies a higher cost per net unit of transported freight than lo-lo service. While, the simpler loading and unloading ro-ro operations (without any quay cranes) make ro-ro service more convenient on short distances.
The shares for the relationships between Italy and Turkey are not in line with the above patterns. The importance of Turkey, in terms of cargo, was due to the robust growth of the Turkish economy, which raised a double-digit increment per year in decade 2010-2019, and to the strong commercial relationships existing with Italy. The Italian port of Trieste is the main gate of freight exported from Turkey towards the central and northern European markets. The maritime freight traffic via ro–ro services between the port of Trieste and some Turkish ports increased from 5.6 million tons in 2010 to 8.8 million tons of freight in 2017.
The results of the update of the model confirm that the “Turkey case” represents an outlier with respect to the general schemes indicated above, for which further information on commercial and economic relations is necessary. The "Turkey case" is considered an outlier value, and the extension of the development and application of the model to other markets is not direct. Turkey's anomalous role is connected with two crucial geopolitical elements: Turkey's participation in NATO; the advanced confrontation for entry into the EU. These two factors have led Turkey to have a privileged relationship with all EU countries. Together with the two geopolitical factors, two factors connected with the structure of the supply are relevant. Turkey's land connections with the economic core of the EU must take place via the Balkan peninsula. These connections are particularly difficult due to the lack of a particularly performing railway axis and to the political instability of some areas crossed. The geopolitical factors increase the demand, the lack of supply by land implies a greater use of sea services, which is so high as to make them an outlier.



Figures 7a-7b. Estimated shares (eq.1) between ro-ro and lo-lo services in import to Italy and in export from Italy. Year 2019.

4. Conclusions

The paper analyses the shares of the two basic components of the SSS market, represented by the ro-ro and lo-lo services. The focus is on SSS services operating between Italy and a set of countries belonging to the south-eastern range of the Mediterranean basin (MENA countries), on which no financial incentives are available.

A discrete choice model simulating the share between ro– ro and lo–lo services has been built, by updating the model parameters by means of observed data of year 2019 using a Generalized Least Square (GLS) estimator. The model was specified and calibrated in the past by means of observed data of year 2010 (see Russo et al., 2016). The results of the parameters' updating confirm the characteristics of the two services, in terms of operating maritime distances. Two main ranges of distances may be identified: below the threshold of 1000 miles, the estimated probabilities of choosing ro–ro services are, in some cases, comparable with the ones of choosing lo–lo services; above the threshold of 1000 miles, the probabilities of choosing lo–lo services are always close to one. The specific variables HUB and SERV, defined in the model (eq. 1) play an important role. The variable HUB captures the increasing competitiveness of SSS lo-lo services, if they operate inside a hub port where direct deep sea connections are present. The variable SERV captures the increasing competitiveness associated to high-frequency SSS ro–ro services existing between a couple of countries.

The work is useful for both researchers and planners, as it could provide ex-ante quantitative analysis to transport planning activities in progress at EU-Mediterranean level, such as the updating of the Trans-European Networks-Transport (TEN-T).

Further work will advance along different directions. The first concerns the development and testing of new model specifications of the service models proposed, by considering time attributes specific of the alternative, geo-politic and economic (GDP) attributes. The second concerns the extension of the model development and application to other EU countries facing the Mediterranean (Spain, France, Greek) and to other Sea Basins, such as the Baltic and the Northern Sea ones in Northern Europe.

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Structural factors that affect the choice between ro-ro and lo-lo mode-services

Discrete choice model among ro–ro and lo–lo mode-services among some Mediterranean countries

Parameters' updating by means of observed data of year 2019 using a GLS estimator

Results confirm the characteristics of the two mode-services in terms of operating maritime distances

Support to transport planning activities at EU-Mediterranean level